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REMOVAL OF INHERITED TENDENCIES TO DISEASE.

By J. R. BLACK, M. D.

A LIMITED collection of statistics and the observation of physicians concur in showing that about two thirds of our people inherit a tendency to some disease, or to a defective vitality in some organ of the body. In very many instances the overshadowing heritage is toward an untimely death, while in others it is simply toward some chronic insufficiency which embitters many a year of life.

The number who think themselves doomed to a premature death by some innate blood defect is very great. At this moment hundreds of thousands are ready to interpret every sign of thoracic derangement as the harbinger to the development of that dreaded inheritance —pulmonary consumption. Taking into consideration that, according to the last census, about seventy thousand throughout our land are swept into the grave each year by this disease, cause for alarm seems sufficiently ample. The aggregate of foreboding, of suffering, and of heart-wringing grief at untimely separations through this scourge alone, would be terrible to contemplate were we capable of apprehending it as a whole. Add to this the heritage in numerous instances of a tendency to rheumatism, to gout, to epilepsy, to insanity, to cancer, and the host of those distressed in mind or in body attains a painful magnitude. A subordinate and large group of heritages are yet to be added. Every year thousands are brought into the world with digestive organs so imperfect that the slightest indiscretion precipitates misery; others are tormented for life by the development of an inherited tendency to *migraine*, to neuralgia, or to asthma; and not a few through the same agency lose their sight or their hearing during the prime of life.

To go on with a bare enumeration of the organic defects handed down from parent to child would occupy many pages. Enough has been said to convey some idea of the magnitude of the evil. There is no cause of grief, of misery and suffering that will bear comparison with it. Even that of war is a mercy compared with the torments of disease. The seventy thousand annually slain by one disease, consumption, involves an amount of suffering which no battle-field can equal. In the latter death is usually sudden, and therefore almost painless, while death by consumption implies months of torture by the destruction of lung tissue inch by inch.

In an age distinguished for progress and philanthropy, that such a gigantic evil has received scarcely any attention is worthy of remark. In large part is this doubtless due to the prevailing opinion that the development of inherited tendencies to disease is unavoidable—a visitation upon children for the sins of the fathers, not to be averted. Even among medical men is there a prevailing skepticism as to the renovation of defective blood. Yet it will be admitted by the candid among them that this doubt is not grounded on a careful study of the subject, but on some desultory observations, and on some remarks to be met with here and there in medical literature. In palliation this may be said, that as a rule physicians are far more intent in discovering the best means of curing than of averting disease, well knowing that the latter is a thankless and little honored pursuit, while the former brings large returns of gratitude and reward.

If in our forty millions of people some twenty-six million inherit some constitutional defect, the question is of deep and wide interest whether such imperfection can be erased, and, if so, by what means. The interests involved are: a nearer extension of life to its normal limits, greater freedom from disease and deformity; a diminution in the necessity for ever-growing asylums for the helplessly imperfect and diseased; an increase of the ratio of able-bodied men for the defense of the state in time of need; a lessened necessity for the consumption of drugs and the support of forty thousand physicians; and an increase and perpetuation of the blood which has been our chief glory as a nation.

The nearer the approach to physical perfection, the less likely will be the occurrence of derangement and disease from slight causes, such as atmospheric vicissitudes, and the greater the chances that the termination of life will be natural, or from the harmonious, progressive, and painless decay of the body as a whole. Death by disease through one organ is abnormal, violent, and torturing; there should be no weak points in the citadel of life. Men with excellent physical organizations do not need to be ever on the watch for the preservation of their health. They possess that buoyancy of life which carries them safely over all the minor influences inimical to healthy action. All that is required of them for the preservation of such a vital excellence is, that

unfavorable influences shall not be too intense, or suffered to act upon them for any great length of time. On the other hand, those defectively organized can not overstep the bounds of the most watchful prudence without incurring suffering. Only by the most minute and accurate knowledge of hygiene, and unswerving attention to its requirements, are they enabled to avoid pain, disease, and an untimely end.

The genius of our civilization in its physiological aspect is to make spendthrifts of us all of our vital riches. It includes no such aim as race improvement. True, some youthful culture of the head and heart is supposed to reach after that object. But it does not. It looks only to immediate success in social distinctions, or to winning in competitive struggles, not to the more remote objects of our improvement as a race. Indeed, the instances in which physical degeneration, by the prevailing injudicious and highly prized head-culture, is not thereby begun, are altogether exceptional. Compare the highly educated son with his father, and a perceptible diminution in the grade of constitutional stamina is nearly always manifest. Continue the process for a generation or two, and a progressive deterioration will ensue until there are only sickly boys to grow up into invalided manhood.

Very few ever think of, and yet fewer ever seek after, the accumulation of vital riches. Only when brought to suffering by poverty of this kind is the mind aroused to any interest in the subject. Prior to the inception of disease, a thoughtless squandering of vital reserve is what our social practices systematically encourage; and when as a consequence corporeal structure is inharmoniously developed, when debility, disease, and untimely death ensue, these are not regarded as the evidences of a fatal flaw in the existing system of civilization, but as matters of prevision which alone concern Providence and the doctors. The constitutional vigor, thus so blindly spent, renders frequent demands upon the highest resources of the healing art urgently necessary. And it must be confessed that in prolonging the life of defective blood there are displayed a skill and care never before equaled. During the more primitive phases of civilization, those of weak and defective blood were more liable to be swept into an untimely grave than they are to-day. Now, all such are skillfully nursed up to the fertile period, to the multiplication and perpetuation of their kind. The profound study, the active sympathy, and systematic charity bestowed upon the wrecks of our race for their cure and preservation, when compared with the prevailing indifference as to the means of preventing the steady increase of such helpless unfortunates, is far from flattering to our foresight in economy and beneficent work. Vast infirmaries, hospitals, and asylums dot the land to shelter and cure the ever-increasing ratio who become pitifully and hopelessly bankrupt in vital condition; yet there is no money, no labor, light, or system brought to bear to hinder this downward career, but very much of all —thoughtlessly we will allow—to aid in its increase and perpetuation.

Optimists assure us that even if insanity, idiocy, deaf-mutism, blindness, and intractable disease and deformity be upon the increase, the evil is not unmingled with good, as it at once serves the twofold purpose of illustrating and exercising the benevolence of the age.

The only rational interpretation that can be put upon the manifestations of defective blood is, that they are the prodroma of its extinction. If the genetic conditions are continuously applied, such will be, as familiar experience often illustrates, the ultimate result; the salient points of the process being, a large infant mortality, death before reproduction, and infertility. On the theory of Dr. N. Allen, that increase of population is mainly governed by the law of approximation to perfection in bodily structure and harmony of function, the postulate can be easily proved that, as a people, we are gradually but surely degenerating. Dr. Toner, the compiler of vital statistics at the national capital, has found that "there is undoubted evidence of a gradual decline in the proportion of children under fifteen to the number of women between fifteen and fifty years of age throughout our country."

The vital statistics of Rhode Island have been carefully and intelligently collected for many years by Dr. Snow, who states that there has been a gradual decline in the birth-rate among those of American parentage for the last twenty years. The same is true of Massachusetts, and, in fact, of New England; the birth-rate being actually lower than in any country of Europe, France alone excepted.

The causes of race degeneration are usually very complex; some pertaining to environment, others to a faulty personal hygiene. Through heredity all the evil effects are accumulated and perpetuated. But fortunately there is a principle in life which tends to antagonize and obliterate the destructive tendency of these innate defects upon life. If nothing of the kind existed—if there were no opposing force—the failure of physiological action would be rapid, uniform, and progressive, until morbid energy gained its fatal mastery over that which tends to hold organic structure in a cycle of harmonious changes.

What is known as reversion, and termed by Darwin "the great principle of inheritance," furnishes the clearest conception of this opposing energy. Of its essential cause nothing is known, but as to its steady operation there is indubitable evidence. In two well-defined conditions of organic life, its steady influence may be observed: in processes that are normal, and in those that are abnormal. The influence of reversion in the perpetuity of normal characters is fully recognized, but the same can not be said of its true relation to those that are abnormal. Writers who have treated upon this point apparently consider the principle as one which tends to restore a lost character without regard to its nature, or, in other terms, that a quality ill suited for the continuance of life, and which has disappeared for one or more generations, is quite as likely to reappear as one well suited. This

conclusion appears to be sustained by ordinary observation, although the conditions which bring about the reappearance of abnormities may be quite different from those which tend to restore lost normalities. The more attentively, however, the subject is considered, the more apparent does it become that the differences in the two cases are far greater than has been supposed, extending back to the antecedents, to the nature, duration, and outcome of the process.

One of the constants of reproduction is more or less variability in the offspring, and this may be healthy or physiological, or it may be morbid. When of the former, it is in no way incompatible with life, and may prove permanent to the blood ; but more commonly it is supplanted by older characters, which may have disappeared for one or more generations. The nature of the prepotent tendency to reversion seems to be grounded upon a single antecedent, that of prolonged transmission. As a rule, it happens that the longer this has occurred the more deeply fixed does any character become, and hence the more likely, when caused to vanish by modifying conditions, to reappear through reproduction.

Exceptionally, it is true, modifying circumstances seem to have so ripened in the organism for a variation that a change of structure and function is uninterruptedly transmitted.

That the prolonged existence of characteristics should tend to fix them strongly upon the blood is in entire harmony with familiar experience. For example, there is nothing permanent in the minute diversities among the individuals of a race, but the general type has long existed, and is preserved for generation after generation with unbroken fidelity. No competent observers think it possible to raise the intellectual grasp of a stupid family or race to the highest average by the culture of one or two generations. Time and continuity of influence are indispensable to the fixing and maintenance of intellectual excellence. To the influence of these elementary conditions is no doubt due the wide disparity between the transmission of instinctive and intellectual skill. In the latter process the thoughts and actions are so numerous and diversified, that the continuance of any one is necessarily short and evanescent, while in the former they are few and always in the same narrow channel. In this way the instinctive brain-impressions of the animal are grooved or deeply stamped into its structure, making their acts a necessary resultant ; while those of intelligence leave but a shallow impress, so that skillful execution can only be attained by individual training and practice.

When the variation that springs from the ripe influence of modifying conditions is of a normal character, it has no inherent quality which renders indefinite perpetuation impossible. Let its favoring conditions be continuously applied, and it may become permanent to the blood, and thus acquire the prepotency of reversion. Quite otherwise is the result with variations of an abnormal or morbid character.

Their presence implies an unceasing and more or less violent struggle between the tendency to an untimely death and the natural term of life. The prolonged existence of such variations, especially when they affect the more important organs, is scarcely possible; progressing in acute attacks, or through descent, either toward reversion or toward lineage extinction. Indeed, if abnormities were in their nature as permanent and compatible with the life of the blood as normalities, they would cease to be such, and all distinctions between them would vanish. Some deviations, however, from ordinary development, such as polydactylism, can not be considered morbid, and are in no way incompatible with the continuance of life.

Organic variability is mainly, if not entirely, an effect of changes in condition. The increased use or disuse of any part, a change from one climate to another, and of the quantity or quality of food, have long been noticed to be specially influential. The various species of domesticated plants and animals are far more variable than the same when wild, a difference readily accounted for by the fact that the latter are far less migrant; their nutriment and the culture of parts undergo little if any change in great lapses of time. Some variations, like that of the loss of wool which our sheep undergo when placed within the tropics, are apparently grounded upon adaptation to relation, others upon adaptation to use, and others are dependent on methodical selection.

One and all of these diverging tendencies are opposed by a single conservative principle, that of reversion. The tendency of animals long domesticated when they become feral to revert to the pristine type might also be supposed to arise from adaptation to relation. But the tendency is often seen when there has been no apparent change in the conditions, as in the many and familiar instances of atavism; and more decisively, by the crossing of species. The experiment of the Earl of Powis is one example of the many which evince the marked tendency to reversion through the crossing of blood. He had some domesticated hump-backed cattle crossed by the wild species from India, with the result, not of producing a medium grade of characteristics, but of a marked reversion to the ancient.* Here, adaptation to relation can not be regarded as effective; only through the indelibility of types by prolonged transmission is such a prepotency explicable.

The principle of reversion is the touchstone of the fitness for survival of blood variations normal in character. If they withstand for indefinite generations the tendency to be supplanted by older and more deeply fixed characters, their fitness is proved, and at the same time they acquire prepotency for strong maintenance against fresh deviations. The principle is therefore eminently conservative, and not a mere blind tendency of the organic processes. Unlike the coarse and obtrusive struggle for existence between independent organisms, it is

* "Animals and Plants under Domestication," vol. ii., p. 19.

a molecular contest of refined organic principles, not visible or audible in its details, but in general scope and outcome as manifest and beneficent in its operation as its more familiar congener.

Though the conservative influence of reversion is quite apparent in variations of a normal kind, it is far more so in those that are morbid or abnormal. Here the struggle between the variation and the tendency to the maintenance of durable types is usually so sudden, violent, and quickly decisive, that it is vividly realized. Upon the tendency of deranged actions to revert into the old channels of health does the therapeutist ground all hopes of his ability to assist in the process. When that is manifestly impotent, no means he can bring to bear will arrest the speedy termination of life. Cullen attributed the tendency in disease to reversion or recovery—for they are identical—to a *vis medicatrix naturæ*. The conception is little more than a barren ideality, and does not accord with the fundamental truth that of causes we can know nothing—only of the relations of phenomena to each other. The *vis medicatrix naturæ* has not been shown to have any antecedent; it is simply a name for a supposed entity, apparently latent until disease appears. According to the views here adduced, it is resolvable into the general principle manifest in all kinds of organic life: the strong tendency to the maintenance of characters which a great lapse of time has proved are the most fit. If this generalization be truly grounded, it adds another to some more notable in which modes of action once considered as produced by independent forces were really transmutations of one.

The frequency with which the principle of reversion gains the mastery in attacks of acute disease is one of the most striking phases of vital action. Form and function are seen to revert to their old types and channels of action as if they had never nearly perished. The struggle against abnormal variations is violent, continuous, but not prolonged. Either the abnormity or reversion quickly gains the mastery; in the former case the end is dissolution, in the latter health. In some instances the morbid variation is slow, insidious, or mild in nature; the struggle is then less conspicuous, more prolonged, but never suspended. When the abnormal variation gains the mastery, it does not survive or establish its fitness by indefinite perpetuation, and so acquire the prepotency of reversion. Untimely death is the signal and sequel of its mastery, and until this or reversion gains supremacy no peace or continued harmony of action is possible. True, blood affected by a morbid variation chronic in its nature often displays sluggish and varying fortunes in its struggle with reversion for mastery; favoring conditions now giving reversion the ascendancy, then unfavorable conditions impart a renewed energy to the unhealthy tendency. Yet a marked lineage struggle for survival is rarely very extended—the compass of a single life's observation not unfrequently witnessing its close.

Morbid variations of structure and function present three leading phases of action, the acute, chronic, and diathetic. The primary causes of each are the same, a faulty personal hygiene and an unfavorable environment, but a derivative cause very generally predominates in the heritage of a defect or taint in the blood. In acute variations the struggle between the tendency to death and the tendency to reversion is usually short and severe, but decisive. The contending forces are often so nearly equal that a very little will turn the scale one way or the other. Chronic variations only differ from acute in this, that they are milder, or are more tolerable to the vital autonomy. The same inherent principle struggles in each for the restoration of health, although the process is not so impressively realized in the chronic as in the acute form, by a rapid and well-defined course. What dissimilarity there is in the two series of actions is wholly one of time and degree, not of nature, the struggle between the tendency to health and the tendency to disease presenting almost every conceivable phase of activity, and lasting from a day to months or even years.

As no one can say precisely when acute diseases end and chronic begin, the distinction being arbitrary and accepted for convenience, no more can any one say exactly when a slow disease is changed into a diathesis. In fact, there are no sound reasons in support of the opinion that such a change ever sharply occurs; but there are in support of this, that a slow disorder is often gradually toned down until it merges into a diathesis, when it is then known as a predisposition. During the gradual disappearance of a slow disease one of untutored and gross perceptions may decide recovery to be complete, while the acute adept may be able to discern the manifestations of the disorder subsequently for months. Indeed, there is scarcely any room for doubt that, if our senses were far more acute, a diathesis or tendency to some special disease would be disclosed in definite signs of imperfection, or of disorder. A diathesis is often seen gradually merging into development, and development into a diathesis, and the frequency with which this is seen to recur in the same person gives tone to the conclusion that the latter state is only a very mild or occult phase of the former. Any ordinary observer, with a predisposition to some disorder, is aware that very slight exciting causes usually serve sufficiently to increase the imperceptible imperfection as to bring it within the cognizance of the senses. But there is yet more indubitable evidence that a series of morbid changes may be going on in the body of which no cognizance can be taken. During the incubative stages of scarlet fever, measles, small-pox, and syphilis, the contagium of each has a definite period of maturative action before the signs of disease are in any way apparent. When a wave of cold air sweeps over a continent it develops in one a pneumonia, in another a rheumatism, in another a fever or an attack of neuralgia, upon the great majority no bad effects whatever. Can it be doubted that some definite imperfection which

constitutes the diathesis must have preëxisted to each of the diseases named, even though it was in no manner obvious to the most careful observer?

Acute, chronic, diathetic, or incubative disease may therefore be regarded as merely expressing the various gradations of morbid processes, from the very rapid to the very slow, from the very severe to the very mild, and from the most readily perceived to the imperceptible.

As acute diseases are only compatible with life for short periods, they are rarely transmitted; in fact, they are excluded from the list of diseases properly inheritable. The open chronic forms of disease, such as scrofula and syphilis, are not unfrequently handed down to the offspring, but far oftener is the heritage of the diathetic grade. This is better tolerated, or more compatible with the continuance of the life in the blood than the open chronic forms which quite commonly render the procreative act abortive.

Before bringing our subject to its practical bearings, it seems necessary that the reader should divest his mind of any vestiges of the glamour of superstition which has so long been around the reproductive process. Darwin succeeds in this with admirable directness by putting reproduction simply as a process of growth. Two cells with somewhat diverse qualities commingle and by gradual accretion develop individual peculiarities. The new self-multiplying stream of blood sometimes appears as if derived in unequal proportions from the two progenitors. This may, however, be supposed to arise from another cause, a temporary or permanent prepotency of the gemmules of one parent over those of the other, which gives them greater activity and power of fission. Be this as it may, every new blood-stream is but a continuation of two older, wonderfully compressed at the junction. The preëxistent forms and forces are only slightly modified by mixture, and by the influence of some variable conditions. In all the general outlines of qualities it is the same blood, exhibiting the same tendencies near or remote to good or to evil, to health or to disease. If there has been a slow struggle—often so subtile as to be at times occult in the parental organism between the tendency to the maintenance of a permanent type and some morbid predisposition—the same is almost certain to be carried on in the blood of the child. The leading causes of any divergence from the continuation of the struggle consist in the crossing of blood, and in the application of modifying conditions when impressibility is at its acme, as from germinal coalescence to adolescence.

With the foregoing facts and deductions in mind, and ranging them around what Dr. Farr terms the great hygienic problem—how to free the people from hereditary disease—the solution does not appear as hopeless and difficult as has been supposed. On the side of release is the great conservative principle of reversion; on the side of continued

subjection are the existing taints or defects of blood, and the continued application of their genetic causes. The third factor is what in political phrase "holds the balance of power." The tendency to the maintenance of durable types is *in limine* more potent than abnormal variations, else recovery would be the exception instead of the rule. But, if the genetic influences of a defect or of an abnormity be kept in continual action after its inception, the ultimate triumph of reversion is a very rare outcome. Great care in acute diseases is commonly taken that the third factor shall not turn the scale against the tendency to reversion, far less is expert systematic supervision as to this brought to bear in chronic disease, while in the diathetic there is as a rule worse than a fitful, or no care—the misjudged application of causes best calculated to increase and intensify the defect or taint in the blood. In illustration of the statement in reference to acute disease, take a case of pneumonia, the result of a protracted out-door exposure to a sudden fall of temperature, with an abundance of atmospheric humidity. Suppose these genetic conditions continued throughout the attack, the likelihood of reversion gaining the mastery would be reduced to a very small ratio. Yet this is the very course generally adopted by those who have a diathetic defect in their blood, actually oftentimes under the belief that it is the best mode of hindering the full development of a dreaded inheritance. Take for example that of pulmonary consumption. Its leading genetic causes are, an in-door sedentary life, unwholesome food for the stomach, and above all depraved and unwholesome air-food for the lungs. Yet the father and mother with this taint in their and their children's veins, realizing that their boys and girls are delicate, from the moment of birth upward seclude them far more than ordinary in close, ill-ventilated rooms, they coddle and pamper them with unwholesome delicacies, and in effect carefully attend to the very conditions which secure weak and foul air as nutriment for their lungs and blood. Thus it is that the precise causes which originate the defect are with more than ordinary assiduity kept in constant action, and the tendency to reversion utterly overwhelmed.

Every candid person will acknowledge that this is no fancy picture, but a true outline of the practices in nearly every household which has such a shadow over it, so that, if the complete supremacy of reversion over a diathesis is not often seen when compared with the frequency with which it gains the mastery over acute disorders, the difference in results is what might be anticipated, as the unfavorable influence of a third factor is brought to bear on the former and not on the latter. The power of reversion in acute disease is readily discerned, the necessity of observing favoring conditions well known ; they are under expert supervision and not difficult to carry into effect. Precisely the opposite is true concerning a diathesis. In chronic disease the struggle between reversion and morbid tendency is often so mild and slow as to be almost imperceptible ; in the diathesis it is as a rule entirely so,

only made obvious now and then before development by some mild aggravating cause, such as, when toward dyspepsia, by slight sensations of discomfort after hearty meals; when toward tuberculosis, by frequent signs of catarrh after ordinary weather-changes.

Not so much by plain evidences to the senses as by mental analysis can the reality of a struggle between a diathesis and reversion to the normal type be apprehended. Yet it is only the *vis medicatrix naturæ* of medical writers carried from the very obvious in acute disease to the less perceptible in chronic, and to the imperceptible in the diathetic. Although the opinion is very generally entertained that those who inherit a diathesis should be careful as to their mode of life, what effect there is on practice is commonly more injurious than beneficial. This arises from the lack of expert supervision, and the sway of some popular traditions as shallow as they are unsound. More frequently does their observance act as aids instead of hindrances to the development of an inherited dyscrasia. Then the observance of the true conditions which favor reversion in an inherited diathesis require no little judgment, self-denial, patience, and intelligence. In acute disease the physician and nurse see that the conditions of reversion are duly observed. Reputation, love, and alarm are all brought to bear for their enforcement. In a diathesis none of these are evoked until the development of all its signs renders the fact apparent that the fatal work has reached its culminating stage. The diathetic subject while in good health is himself indifferent and incredulous as to his danger. For the young to be always as careful of their health as an invalid, in other words, not to live and do as the careless multitude, presupposes unusual self-denial and discretion. Obstacles like these not only thwart the principle of reversion, but contrariwise strengthen and evolve abnormal variations.

Advantage being carefully taken of reversion in acute disease, less so in chronic, and scarcely at all in diathetic, that the eradication of unfortunate inheritances should have received so little credence is the natural outcome of the prevailing ignorance or neglect of the conditions. It is well, however, to bear in mind that this prevailing belief is simply and wholly the result of antecedents as they are and have been, not as they might and should be.

The instances in which the operation of the law of reversion has had anything like an unimpeded sway are far more commonly casual than designed. Circumstances render a change of environment and habits of life necessary or desirable, and these may happen to include its favoring conditions, or they may not. Those who recover from the tendency to an abnormal inheritance through intelligent design ought to be found, if anywhere, in the ranks of the medical profession, and especially among those of them who have given the science of health no little attention. A work assigned me by the American Medical Association brought some statements under my eye which confirm this

inference in the most unmistakable manner. I select a few examples in reference to the tuberculous diathesis, at once the most prevalent, the most liable to be transmitted, and, according to the prevailing opinion, the least amenable to preventive measures.

A quite old and widely known physician makes this statement: "My father and mother were cousins. Father had hæmoptysis at twenty-eight, and was supposed dying of consumption, but recovered, and died in his sixty-seventh year of cancer of the stomach. He had cicatrices in his lungs. Mother died of phthisis late in life, having given birth to six children. These are all alive. No consumption in any of them, nor in twenty-seven grandchildren and fourteen great-grandchildren."

Another highly reputable physician writes: "On maternal side evident tendency to tuberculosis. My only brother—I had no sister—died of phthisis, aged twenty-six. I had hæmoptysis, with cough, repeatedly, between the ages of twenty-two and thirty-five. Wife healthy, and gave birth to five children—ages between thirty and forty-eight. None of them, nor eight grandchildren, have exhibited any signs of pulmonary consumption."

Another writes: "Consumption on father's side, having lost one if not two sisters by the disease. Mother died of it in her forty-third year. Six children were born to them—all alive and healthy, the youngest past his fiftieth year. They are all free from any signs of tuberculosis, as are also thirty-one grandchildren and eleven great-grandchildren."

Yet another writes: "Father died of paralysis, mother of consumption; also one of her brothers. Grandmother also died of what is presumed to have been the same disease. Of seven children, varying from forty to sixty, none have shown any pulmonary disease."

These statements are made by physicians well known for their interest in sanitary science. Through their knowledge and influence, they and their kin have been able to take a wise advantage of the power of reversion. As there are hundreds of thousands throughout the land who have this fearful taint in their blood, a knowledge of the true conditions for its renovation becomes of great importance. It is not within the scope of this paper to enter upon details, but this much may be said, that intelligent and unwavering hygienic observances all through life, but especially from birth to adolescence, constitute the cardinal requisites. Not the hygiene, however, taught in almanacs, in gossipy newspapers, or by itinerant sensational lecturers, but by the most accomplished scientists. A thorough mastery of its principles and details, so as to secure a correct application of them at the various periods, emergencies, and contingencies of life, is absolutely necessary. In short, those with an unfortunate inheritance—like those suffering from an attack of disease—need the knowledge of an expert to enable them to take a wise and full advantage of the principle of re-

version. If this be attained, and applied vigilantly and continuously, there is, I have no doubt, far more probability of recovery from an unfortunate inheritance than from an attack of ordinary disease. The chief peril in the latter condition lies in the severity of the struggle, the ground of safety in the former in its mild prolongation, whereby the law of reversion can have unimpeded opportunity through the long and steadfast application of favoring conditions to restore the body to its pristine vigor. The thought may occur that not many have the requisites alleged to be needful for the restoration of defective blood. Yet even this has an outcome not to be deplored. High intelligence, and a will subordinate to it, will survive; while feeble minds and groveling instincts will carry the blood on to overt disease, to untimely death, and to extinction.

THE STORY OF THE NOVEMBER METEORS.*

By G. JOHNSTONE STONEY, F. R. S.

WHEN observers band together to watch every quarter of the sky, and to keep on the lookout through the whole night, the number of meteors that present themselves is very great. In this way it has been ascertained that upward of thirty on the average, which are conspicuous enough to be seen without instruments, come within the view of the observers stationed at one locality. And it is computed that telescopic meteors must be about forty or fifty times as numerous as those visible to the naked eye.

These results may be obtained from observations made at one station; but when concerted observations are carried on at different stations several other facts of interest come to light. By simultaneous observations at distant stations, it has been discovered that the height of meteors above the surface of the earth usually ranges from one hundred and twenty down to twenty miles, the average height being about sixty miles; that the direction of their flight is toward the earth, either in a vertical or in a sloping direction; and that their speed in most cases lies between thirty and fifty miles a second.

We thus arrive at the conclusion that *visible* meteors are phenomena of our own atmosphere; and as the atmosphere reaches a height, at most, of one hundred and fifty miles, and is, therefore, but a thin film over so vast a globe as the earth, it is obvious that the spectators at any one place can see only a very small portion of the meteors which dart about through all parts of this envelope. After making allowance for this, we are forced to conclude that no fewer than 300,000,000

* Lecture before the Royal Institution, February 14, 1879.

of these bodies pass daily into the earth's atmosphere, of which about seven millions and a half are large enough to be seen with the naked eye on a clear night, and in the absence of the moon.

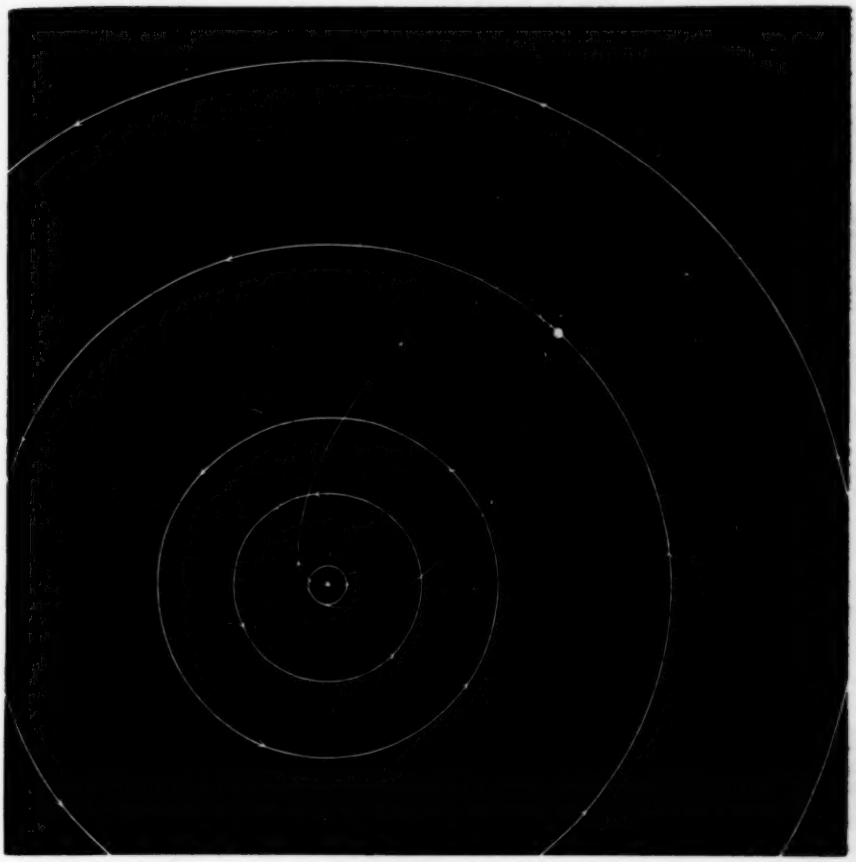
From the direction and swiftness of their flight, it is manifest that meteors are visitors from without. They plunge into our atmosphere, and the resistance to which they become then suddenly exposed must raise them to a temperature which exceeds that of the most intense furnace. The heat is enough first to melt and then to dissipate in vapor the most refractory substances, and it only now and then happens that even a part of a meteor escapes this fate, and reaches the ground. They are for the most part lost in vapor ere they get within several miles of us. The difficulty, indeed, is not to account for their incandescence, but to see why they do not emit a greater flood of light where the heat must be so intense. And, in fact, they can not be other than very small bodies, or they would be much brighter. The average weight of those visible to the unassisted eye appears to be under an ounce, and the telescopic ones, of course, are much lighter.

Meteors may be distributed into two very obvious classes—casual meteors, which dart irregularly through the sky, and meteoric showers, which stream into our atmosphere in one definite direction, and at stated intervals of time. We are concerned at present with the meteoric showers. Many such are known to exist, of which the principal are the August shower, through which the earth passes every year upon the 9th, 10th, and 11th of August, and the great November shower, which is discharged upon the earth three times in a century. The November meteors are those about which most is known, and it was of these, therefore, that the lecture chiefly treated.

To make their history intelligible, it is necessary to explore, in some degree, the regions from which they come. For this purpose your attention is called to this great diagram, every hundredth of an inch upon which represents a distance in nature equal to the interval between the earth and the moon.* The distance from the earth to the sun on this diagram is a decimetre, that is, four inches; and, on the same scale, the nearest fixed star would have to be placed at a distance of twenty kilometres, or upward of twelve miles.

In these vast celestial spaces, there are no rails over the roughnesses of which the train must be made to rattle, if it is to move at all; there are no wheels to be worn out; there is no air in which a wind must be produced, or through which noise will be propagated. The music of the spheres is not a sound audible to the ear, and an impediment to motion: it is harmless, it is altogether good, it is the pleasure of the human mind when it understands the great works of nature. There is no thundering along through the heavens. All is silence and peace round the planets as they swiftly glide. Bodies which sweep

* The scale of the diagram exhibited was rather more than forty times the scale of the accompanying woodcut.



in this way without obstruction through the depths of space, are ready to yield at once the due amount of obedience to the attraction of the sun. Accordingly, each meteor which traverses the elliptic orbit represented in the diagram, mends its pace so long as it is gliding along that half of its course in which it is approaching the sun, because here the sun is drawing it forward as well as sideways; and the forward attraction increases its velocity, while the sideward attraction bends its path into the oval form. The meteor takes upward of sixteen years to traverse this part of its orbit, and all this time its velocity is on the increase. It has attained its greatest speed when it reaches the point of its orbit which is closest to the sun, near to which is the place where it crosses the earth's path. As it passes this point its velocity is twenty-seven miles a second. The earth moves at the rate of nineteen miles a second in very nearly the opposite direction, so that if the meteor happen to strike the earth, the velocity of its approach is the sum of these two numbers, or forty-six miles a second; and it is at this enormous speed that it plunges into our atmosphere.

But if it escapes the earth, and continue its course along its orbit, it loses speed for the next sixteen years, until it passes the farthest part of its orbit at its slowest pace, which is about a mile and a third per second. In each revolution its velocity oscillates between these extremes. Its orbit is so vast that it takes thirty-three years and a quarter to get round it.

Such is a good picture of the course pursued by each member of the great November swarm. There are countless myriads of meteors in this mighty group, each one moving independently of the rest, each one fulfilling its own destiny. They form, together, an enormous stream of meteors, the dense part of which appears to be about 100,000 miles in width, and of immense length. The orbit along which they travel was represented on the diagram by an ellipse of 207 centimetres, or close upon seven feet, long—i. e., by an oval about as long and broad as the hall-door of a house; and the length, breadth, position, and motion of the swarm in 1865, before it reached the earth, would be represented on the same scale by a thread of the finest sewing-silk, about a foot and a half or two feet long, creeping inward along the orbit, the rear of the column having been between the orbits of Jupiter and Saturn, and the front of it nearly as far in as the earth's orbit. The actual train which is thus represented was so amazingly long that even moving at the rate of twenty-seven miles a second, it took upward of two years to pass the point where its path crosses the earth's orbit. The earth passes this point on the morning of the 14th of November in every year. The head of the dense part of the stream seems to have reached the same point early in the year 1866. The earth was then in a distant part of its orbit, but on the following 14th of November we came round to the place where the great stream of meteors was pouring across our path. The earth then passed through the swarm, just as you might imagine a speck, too small to be seen by the eye, to be carried on the point of a fine needle in a sloping direction through the thread which represents the meteors. The earth took about five hours to pass through the stream; and it was Europe, Asia, and Africa, which happened at the time to be moving forward. Accordingly, it was upon this side of the earth, on that occasion, that the meteors were poured, and they produced the gorgeous display in our atmosphere which many here must remember. In 1867, when we came round again to the same place, the stream of meteors was still there. America, this time, chanced to be the part of the globe which was turned in the right position to receive the shower. In 1868 the mighty swarm had not passed, and in subsequent years, when we came round to the proper place, we still found ourselves among outlying stragglers of the great procession.

In 1799 Humboldt was traveling in South America, and on the morning of the 12th of November in that year the November shower was poured out over the New World. Humboldt's description of this

shower seems first to have fixed the attention of scientific men upon the subject. But he contributed still more to the advance of our knowledge by the success with which he insisted that nearly all such phenomena are periodic, and that therefore there is reason to hope that the causes of them are discoverable. Shortly after, the periodic character of the August meteors was established; and when the next return of the November meteors to the earth took place, when there was a magnificent display of them exhibited to Europe in 1832, and a still more impressive spectacle seen in America in the following year, the attention of scientific men was thoroughly aroused.

In England meteors began to be systematically observed, and in this way all that knowledge about them has been acquired which was referred to in the beginning of the lecture. In France the records of antiquity and the annals of distant nations were ransacked; and by this most useful antiquarian search, no less than ten visits of the November swarm, previous to the shower observed by Humboldt in 1799, have been brought to light. But the first great step toward gaining a knowledge of their orbit was made by Professor H. Newton, of New Haven, in America, who published in 1864 two memoirs, in which he discussed all the accounts that had been collected, extending back to the year A. D. 902. He found, by comparing the dates of the old observations with the modern ones, that the phenomenon is one which recurs three times in a century, or, more exactly, that the middle of the swarm crosses the earth's path at intervals of thirty-three and a quarter years. He further showed that meteors which thus visit the earth three times in a century must be moving in one or other of five orbits which he described; and that therefore, if means could be found for deciding between these five orbits, the problem would be solved. The five possible orbits are—the great oval orbit which we now know the meteors actually do traverse every thirty-three and a quarter years; a nearly circulat orbit, very little larger than the earth's orbit, which they would move round in a few days more than a year; another similar orbit in which their periodic time would be a few days short of a year; and two other small oval orbits lying within the earth's orbit. But we owe even more to Professor Newton. He also pointed out how it was *possible* to ascertain which of these orbits is the true one, although the test he indicated was one so difficult of application that there was at the time little hope that any astronomer would attempt it. Fortunately, our own Professor Adams, of Cambridge, was found able to grapple with the difficulties of the problem, and willing to encounter its immense labor, and to him we owe the completion of this great discovery.

A comparison of the dates of the successive showers which have been recorded shows that the point where the path of the meteors crosses the earth's orbit is not fixed, but that every time the meteors come round they strike the earth's orbit at a point which is twenty-

nine minutes (i. e., nearly half a degree) farther on in the direction in which the earth is traveling. In other words, the meteors do not describe exactly the same orbit over and over again: their path in one revolution is not exactly the same as their path in the next revolution, although very close to it. Thus, their path in A. D. 126 was that which is represented by the strong oval line in the diagram, but, in the seventeen centuries which had since elapsed, it has gradually shifted round into the position represented by the dotted ellipse. This kind of motion is well known to astronomers, and its cause is well known. It would not happen if the sun were the only body attracting the meteors, but arises because the planets also draw them in other directions; and although the attraction of the planets is very weak compared with the immense power of the sun, still they are able to drag the meteors a little out of their course round the sun, and in this way occasion that shifting round of the orbit of which we are speaking. Now, in the case of meteors which are really traveling in the large orbit, this shifting of the orbit must be due to the attraction of the planets Jupiter, Saturn, Uranus, and the Earth, while, if they had traveled in any of the four smaller orbits, the planets that would be near enough and large enough to act sensibly upon them would be the Earth, Venus, and Jupiter. Accordingly, if any one could be found able to calculate how much effect would be produced in each of the five cases, the calculated amount of shifting of the orbit could be compared with the observed amount, which is 29′ in thirty-three and a quarter years, and this would at once tell which of the five possible orbits is the true one.

These papers of Professor Newton's were published in 1864. Before the computations which he had indicated could be attempted, it was necessary that the direction in which the meteors enter the earth's atmosphere should be known much more accurately than it then was, in order to enable astronomers to compute the *exact* forms and positions of the five possible orbits. This observation, then, was of the greatest importance in 1866, and it was on this account that all the astronomers on that occasion devoted nearly all their efforts to determining with the utmost precision the exact point of the constellation Leo from which the meteors seemed to radiate. This important direction was ascertained during the great meteoric shower on the morning of the 14th of November, 1866, and immediately after Professor Adams and his two assistants in the Cambridge Observatory set to work at their arduous task. This great calculation required the solution of a problem in mechanics which had never before been attempted, and involved an immense amount of tedious labor. Amid all these difficulties Professor Adams triumphed; and after months of toil he was able to announce in the following March that, if the meteors are moving in the large orbit, Jupiter would produce a shifting of the orbit in each revolution amounting to 20′, the attraction of Saturn

would add to this 7′, Uranus would add 1′; the effect of the earth and other planets would be insensible. Adding these numbers together, the whole effect, according to Mr. Adams's computation, is 28′, almost exactly the same as the observed amount which had been determined by Professor Newton, which was 29′. But, if the meteors were in any of the other four possible orbits, the total amount would never exceed 12′. Here, then, we have reached the final result: *the long orbit is the orbit of the meteors.* This great discovery was published in March, 1867.

Meanwhile Signor Schiapparelli, of Milan, was laboring in another direction. It was evident from the observations that the meteors were drawn out into a long stream. What was the cause of this? Signor Schiapparelli pointed out that if a cloud of meteors were started under conditions which are not quite the same, each meteor would pursue its own orbit, which would differ from the others. If they were treated almost exactly, although not quite, alike at starting, their various orbits would lie excessively close to one another, and would be undistinguishable in most respects. But if there be any effect which goes on accumulating from revolution to revolution, such an effect would in the end become very sensible. And such an effect there is. The periodic times differ a little in these different orbits. At the end of the first revolution those meteors which have the longest periodic times are the last to get back to the starting-point, and have, therefore, already fallen a little into the rear of the group, while those with the shortest periodic time have gone a little ahead. At the end of the second revolution the separation is doubled, and in each successive revolution the column is still more lengthened out. After a sufficient number of revolutions it will be spread out over the whole length of the orbit, and form a complete oval ring. This has not yet happened to the November meteors, and we are thus assured that it can not be any enormous period, speaking cosmically, since the time when they first started on their present path. On the other hand, the August meteors, which have returned punctually *every* year since they were first observed, are probably a complete ring, and are at all events of far greater antiquity than the November meteors. But they are also, as might be expected, more scattered, so that the sprinkling of meteors they discharge upon the earth as it passes through them has nothing like the splendor of the great November shower. Signor Schiapparelli also pointed out that there is a comet moving in the track of the August meteors, and another in the track of the November meteors. We shall presently see the significance of this observation.

The next great step was made by M. Le Verrier, the late Director of the Paris Observatory. Acting on the suggestion made by Signor Schiapparelli, M. Le Verrier pointed out that the orbit of the meteors intersects the orbit of Uranus, as represented in the diagram. From

its inclined position it does not intersect the path of any of the intermediate planets Saturn, Jupiter, and Mars. M. Le Verrier also calculated back the epochs at which the planet and the meteors were at the point of intersection, and found that early in the year A. D. 126 they were both at that spot, but that this has not happened since. Taking this in conjunction with what Signor Schiapparelli pointed out, we seem to have a clew to a truly wonderful past history. All would be explained if we may suppose that, before the year 126, the meteors have been moving beyond the solar system; and that in that year they chanced to cross the path of the planet Uranus, traveling along some such path as that represented in the diagram. Had it not been for the planet, they would have kept on the course marked out with a dotted line, and, after having passed the sun, would have withdrawn on the other side into the depths of space, to the same measureless distance from which they had originally come. But their stumbling on the planet changed their whole destiny. Even so great a planet would not sensibly affect them until they got within a distance which would look very short indeed upon our diagram. But they seem to have almost grazed his surface, and, while they were very close to such a planet, he would be able to drag them quite out of their former course. This the planet Uranus seems to have done, and when, pursuing his own course, he again got too far off to influence them sensibly, they found themselves moving slowly backward, and slowly inward; and accordingly began the new orbit round the sun, which corresponds to the situation into which they had been brought, and the direction and moderate speed of their new motion.

They seem to have passed Uranus while they were still a small, compact cluster. Nevertheless those members of the group which happened to be next the planet as they swept past, would be attracted with somewhat more force than the rest, the farthest members of the group with the least. The result of this must inevitably have been that, when the group were soon after abandoned to themselves, they did not find themselves so closely compacted as before, nor moving with an absolutely identical motion, but with motions which differed, although perhaps very little, from one another. These are conditions which would have started them in those slightly different orbits round the sun, which, as we have seen, would cause them, as time wore on, to be drawn out into the long stream in which we now, after seventeen centuries, find them.

What is here certain is, that there was a definite time when the meteors entered upon the path they are now pursuing; that this time was the end of February or beginning of March in the year 126 is still a matter of probability only. It is, however, *highly* probable, because it explains all the phenomena at present known; but astronomers are not yet in a position to assert that it is ascertained, since one link in the complete chain of proof is wanting. We who live now should be

in possession of this link if our ancestors had made sufficiently full observations; and our posterity will have it when they compare the observations they can make with those which we are now carefully placing on record for their use. They will then know whether the rate at which the stream is lengthening out is such as to indicate that A. D. 126 was the year in which this process began. If so, Le Verrier's hypothesis will be fully proved.

Another episode in the eventful history of these meteors is also known with considerable probability. It has been already mentioned that a comet is traveling along the same path as the meteors. It is moving a very little slower than they, and is at present just at the head of the procession which they make through space. Another comet is similarly moving in the track of the great elliptic ring of August meteors. In 1867 the lecturer ventured to suggest an important function which these comets seem to have discharged. Picture to yourselves a mass of gas before it became connected with the solar system, traveling through space at a distance from the sun or any other star. Meteors would now and then pass in various directions, and with various velocities, through its substance. For the most part they would go entirely through and pass out again; but in every such case the meteor would leave the comet with less velocity than it had when approaching it. And in some cases this reduced velocity would be such that the future path of the meteor would be an ellipse round the comet. Whenever this was once brought to pass, the meteor would inevitably return again and again to the comet, each time passing through some part of its substance, and at every passage losing speed. After each loss of speed the ellipse it would next proceed to describe would be smaller than the one before, until at last the meteor would sink entirely into the gas and be ingulfed by it. In this way meteor after meteor would settle down through the comet, and, in the end, just such a cluster would be formed as came across the planet Uranus in the year 126, or, if such a cluster existed originally within the mass of gas, it would in this way be augmented. As the comet swept past the planet, its outlying parts would seem to have grazed his surface, and in this way the gas was probably somewhat more retarded than the meteors; and in the centuries which have since elapsed the meteors have gone so much ahead of the comet that they are now treading on his heels and on the point of overtaking him, while probably the gas has again brought together a smaller cluster of the meteors.

The question now arises, How the deserts of space which extend from star to star come to be tenanted here and there by a patch of gas or an occasional meteorite? Light has been thrown on this inquiry by discoveries made with the spectroscope in modern times and by observations during eclipses. These have revealed to us the fact that violent outbursts occur upon the sun, and doubtless on other

stars, so swift that the up-rush must sometimes carry matter clear away into outer space. Imagine such a mass consisting in part of fixed gas and in part of condensable vapors ejected from some star. As it travels forward the vapors cool into meteorites, while the fixed gas spreads abroad like a great net, to entangle other meteors. In some cases both might travel together; in others the gaseous portion would be retarded before it passed beyond the neighborhood of the star, and the denser meteors would get ahead. But even so in the lapse of ages other meteors would be caught, so that in any event a cluster would at length be formed. Now, the reasonable suspicion that this is the real origin of meteors has received striking confirmation from the discovery of the late Professor Graham, that meteoric iron contains so much hydrogen occluded within it as indicates that the iron had cooled from a high temperature in a dense atmosphere of hydrogen—precisely the conditions under which the vapor of iron would cool down while escaping from a large class of stars, including our sun.

We have now traced an outline of the marvelous history of these Arabs of the sky. We have met with outbursts upon stars sometimes of sufficient violence to shoot off part of their substance. We have found the gaseous portion sweeping through space like a net, and the vapors that accompanied it condensed into spatters that have consolidated into meteorites. We have seen this system traveling through boundless space, with nothing near it except an occasional solitary meteor, and we have seen it in the long lapse of ages slowly augmenting its cluster of these little strangers. As it wandered on it passed within the far-spreading reach of the sun's attraction, and perhaps has since been millions of years in descending toward him. Its natural course would have been to have glided round him in a curve, and to have then withdrawn to the same vast abyss from which it had come; but, in attempting this, it became entangled with one of the planets, which dragged it out of its course and then flung it aside. Immediately, it entered upon the new course assigned to it, which it has been pursuing ever since. After passing the planet the different members of the group found themselves in paths very close to one another, but not absolutely the same. These orbits differed from one another very slightly in all respects, and among others in the time which a body takes to travel round them. Those meteors which got round soonest found themselves, after the first revolution, at the head of the group; those which moved slowest fell into the rear, and the comet was the last of all. Each succeeding revolution lengthened out the column, and the comet soon separated from the rest. Fifty-two revolutions have now taken place, and the little cloud has crept out into an extended stream, stretching a long way round the orbit, while the comet has fallen the greater part of a revolution behind. We can look forward too, and see that in seventeen centuries more the train

will have doubled its length, and that ultimately it will form a complete ring round the whole orbit. When this takes place, a shower of these meteors will fall every year upon the earth, but the swarm will be then so scattered that the display will be far less imposing than it now is.

Such is the history of one of the many meteoric streams which cross the path of the earth. There are several of these streams, and no doubt the story of every one of them is quite as strange. And if there are several streams of meteors, which come across that little line in space which constitutes the earth's orbit, what untold multitudes of them must be within the whole length and breadth of the solar system! Perhaps it may even turn out that the mysterious zodiacal light which attends the sun is due to countless hordes of these little bodies flying in all directions through the space that lies within the earth's orbit.

THE RE-EDUCATION OF THE ADULT BRAIN.

By WILLIAM SHARPEY, M. D., LL. D., F. R. S.,
EMERITUS PROFESSOR OF ANATOMY AND PHYSIOLOGY, UNIVERSITY COLLEGE, LONDON.

MRS. H——, the subject of the following case, is about twenty-four years of age,* of a pale complexion and slender make. She was married in July, 1823, and, with the exception of occasional headaches to which she, in common with some of the rest of her family, was subject, and slight bowel complaints, she previously to that time enjoyed good health, both of body and mind. After her marriage she resided in England till the end of April, 1824, when, in consequence of ill health, she was brought here by her husband, on a visit to her friends who live in this neighborhood,† and with whom she had passed a great part of her previous life. From her husband's account, it appeared that for about three months after their marriage she enjoyed perfect health and spirits, but that after that time she complained a good deal of pain in her stomach and bowels; her appetite was bad, she began to lose spirits, imagining herself unequal to the concerns of the house, though her family consisted only of herself and her husband; and now also it was observed that she slept more than usual. The medical gentlemen consulted, believing some of her complaints might be owing to an affection of the liver, administered mercury in small quantities and applied leeches to the temples in considerable numbers, with a view to relieve an uneasy feeling of lightness which she complained of in her head; but these remedies proved of little or no avail, and for some time before leaving England, excepting a laxative which she

* This was written in 1824.

† Arbroath, Forfarshire.

took twice a week, she had given up the use of medicine altogether. No probable cause could be assigned for these complaints.

On her arrival in this place, which, as already mentioned, was about the end of April last, she had lost but little flesh, and by no means looked sickly; indeed, she was little, if at all, changed in her appearance; all her external senses were sound, but her memory was impaired, and she was very inattentive to surrounding objects, which made her dull and absent in company. The sleepiness had been very gradually increasing, and was now arrived at such a height that, unless when conversing with another person, or engaged in some manual occupation, she fell asleep at all times, and in whatever situation or position she might be. When in this state her eyes were nearly closed, she breathed softly, and, in short, very much resembled a person in natural sleep, except that when she happened to fall asleep in a position in which the body naturally requires to be supported, as for instance on a chair, she did not lean forward or backward as is commonly the case, but sat with her body quite erect, and her head gently inclined to one side. While in this state she was subject to frequent startings, during which she raised herself up, talked as if she were frightened, drew herself back as if to avoid something disagreeable, and then after a few seconds lay quietly down again without having waked. What she said on these occasions, though quite incoherent, was yet always nearly of the same nature, and for the most part consisted even of the same expressions, which were those of great aversion or horror; of this she had no recollection when awake, nor of anything connected with it; and she herself remarked as something extraordinary that now she did not dream, although she used formerly to be very subject to dreaming. From this sleep she never awoke of her own accord, except to obey the calls of nature; and there was no other way of rousing her up upon other occasions, but by placing her on her feet and endeavoring to make her walk. When thus forcibly awakened, she was fretful, and cried for some time after. She took food in sufficient quantity, and often with evident relish; but it required much entreaty to make her take the first two or three mouthfuls. The pulse varied a little, but on the whole was nearly natural; during sleep it was commonly from fifty-six to seventy, and somewhat more when awake. Her bowels were very costive, and constantly required the use of laxative medicine; the discharge of urine was natural; the catamenia had hitherto been regular in their appearance, but in small quantity. She complained of no pain or other uneasiness, except a peculiar feeling in the top of the head across the bregma, which she called "funny."

For five weeks after her arrival the torpid state and indifference to surrounding objects continued gradually to become worse, and the difficulty of awakening her daily increased; till at length, about the 8th or 10th of June, it was found impossible to rouse her up at all by

any means that could be thought of; and from that time forth, excepting a few short intervals, she remained in a state of constant sleep till the beginning of August. Her condition was now singular enough. She still made an attempt to get out of bed when she required to go to stool; when food was presented to her lips with a spoon, she readily took it into her mouth and swallowed it, and in this way she was fed as long as the torpor continued; when she had taken what appeared a sufficiency, she closed her teeth as a sign she was satisfied, and if importuned to take more, turned away her mouth from the spoon. She appeared also to distinguish different tastes, for she gave an evident preference to some sorts of food and obstinately refused others. She sometimes even, to all appearance, judged of the nature of the food or medicines offered to her, by the sense of smelling; and, when the latter were such as possessed a strong odor, she would often close her mouth in a determined manner before they touched her lips.

By this time the startings in her sleep had left her; and although the expressions she uttered when in that state were, with some slight additions, nearly the same as formerly, yet her manner of speaking was now indicative of satisfaction and not of fright. She often even sang to a simple but cheerful air nearly the same words which she used formerly to cry out with every appearance of the greatest terror.

The torpor continued nearly in the same degree till the end of July, with occasional intervals of waking, which happened at uncertain periods, but generally at the distance of a few days from each other, and were occasioned by pain experienced in some part of her body. The first of these took place after she had been ten days in a continued state of torpor; it was caused by severe griping from laxative medicine. She awakened in great suffering, crying out, "Pain! pain!" "Die! die!" and placing her hands on the abdomen. She was relieved by means of warm fomentations; but she, notwithstanding, kept awake for some hours after, during which time she answered no question, in however loud a voice it was put to her, and recognized nobody except one old acquaintance, whom she had not seen for more than twelve months. She looked steadfastly in this person's face for a few seconds, apparently occupied in trying to remember his name, which at length she found out and repeated again and again, at the same time taking him by the hand as if overjoyed to see him; but when questioned regarding him, she answered only by calling out his name, which she continued to repeat for some time after she had fallen asleep, in addition to what she usually said. In the course of the next eight days she was twice roused from her sleep by a similar cause, but not so completely; the same individual was still the only person she knew; among others she did not recognize even her own husband, who happened then to be in Scotland.

The next interval of waking took place three or four days afterward; it appeared to be occasioned by pain in the head. She cried

for some time, then awoke, complaining of pain, with her hand on the fore part of her head, on which also she placed the hand of a person near her and pressed it down firmly with her own; after thus complaining for two or three hours, she fell asleep. The same thing happened on the next and the two or three succeeding evenings, nearly at the same hour, but each time with less complaint. Other circumstances about this time showed that she was suffering considerable uneasiness in her head. She was very impatient in the erect posture, and, when lifted out of bed, would not put her feet to the ground, but drew up her legs to her body, as if to force those who held her to lay her down again. This, however, was not the case when she required to be taken up for the purpose of making any evacuation. She generally also preferred to lie on her face, and always with her head very low, with both hands firmly clasped over it, exactly on the part to which she had formerly referred the peculiar feeling already mentioned, and showed much uneasiness when they were removed, unless the pressure was continued by the hand of another person.

After this, the torpor continued for some time without being interrupted; but in the mean time the symptoms of pain in the head, and the uneasiness in the erect posture, gradually wore off, and Mrs. H—— now no longer talked in her sleep. Her bowels were kept open by laxative medicine, which now did not operate so severely as to wake her. She had, since the beginning of June, had a blister applied to the nape of the neck, and three to the head at different periods; sinapisms to the feet were also had recourse to, and two or three times electric shocks were passed through her arms. These remedies, like other painful stimulants, caused her to complain much; and one of the blisters, which was sufficiently large to cover the whole scalp, made her open her eyes; but their effects were merely temporary, leaving, to all appearance, no permanent impression on her complaint. Lest there might be any serous effusion within the cranium, digitalis was used along with the sweet spirit of niter, in such quantity as greatly to augment the flow of urine. By its operation her pulse was reduced so low as forty-four in a minute; and, while using it, she appeared to suffer from sickness at the stomach, during which she often put her fingers into her mouth, as if wishing for something to eat or drink; and she was subject to what seemed an oppressive feeling in the region of the heart, with a peculiar interruption to her breathing, which came in paroxysms; all which symptoms left her after discontinuing the medicine.

Toward the latter end of July, the torpid state, which had suffered no more intermissions, was become on the whole not quite so deep; at least Mrs. H—— now gave signs of being more conscious of anything that was done to her. She smiled and seemed pleased on receiving particular sorts of food, and when her eye was opened, or any part of her face touched with a finger, her whole countenance became suffused with

a blush of redness. Some short time after, it became possible to awake her by opening her eyes, and holding anything before them likely to catch her attention, such as a glass of water, a cup, or the like. When awakened in this way, which succeeded best at the times she was getting her food, she generally laughed a good deal and seemed much delighted, and she always bestowed her whole attention on the vessel in which her food or drink was contained, and the person who held it; she, however, did not speak, and paid no attention whatever to the questions put to her. One day about this time, viz., on the 1st of August, in consequence of her usual medicines failing in their effect, she had two or three laxative clysters, and then a small dose of croton-oil, which produced very copious evacuations, but at the same time caused so much griping as to wake her. When suffering from this, she took hold of the blankets of her bed, twisted them in her hands, and applied them over the abdomen, looking wistfully all the while in the faces of the attendants, as if she had recollected the fomentations which had formerly given her relief, and wished them to be had recourse to on the present occasion; her wish was complied with, with the effect of removing the pain, which seemed to give her great satisfaction. In two or three days after this the torpor was much diminished, and she could be awakened with great ease. She likewise began to take a great liking to the young woman who waited on her, so much so that, when awake, she would hardly allow her to be a moment out of her sight. Now also she would sometimes let herself cautiously down on the floor from her bed, and creep to the fireside, where she would lay herself quietly down on the hearth-rug, as if she wished to enjoy the warmth of the fire.

At length, after progressively improving for some days, she was by the third week in August almost free from torpor, and slept little more than a person in health. During all this period, except that her feet were sometimes cold, the temperature of her body was very nearly natural. Her face was for the most part pale, but sometimes a little flushed, and the pupil of the eye uniformly contracted on exposure to the light. Her pulse, which had been rendered slow by the digitalis, was observed to be rather higher for some time preceding her recovery than it had been even before the use of that medicine. She had undoubtedly lost flesh during her illness, but at this time she was not so thin as she had been a short time before. The catamenia had not appeared since the month of May; but, with the exception of considerable loss of strength, her bodily health was now on the whole tolerably good.

On her recovery from the torpor she appeared to have forgotten nearly all her previous knowledge; everything seemed new to her, and she did not recognize a single individual, not even her nearest relatives. In her behavior she was restless and inattentive, but very lively and cheerful; she was delighted with everything she saw

or heard, and altogether resembled a child more than a grown person.

In a short time she became rather more sedate, and her attention could be longer fixed on one object. Her memory too, so entirely lost as far as regarded previous knowledge, was soon found to be most acute and retentive with respect to everything she saw or heard subsequently to her disorder; and she has by this time recovered many of her former acquirements, some with greater, others with less facility. With regard to these, it is remarkable that though the process followed in regaining many of them apparently consisted in recalling them to mind with the assistance of her neighbors, rather than in studying them anew, yet even now she does not appear to be in the smallest degree conscious of having possessed them before.

At first it was scarcely possible to engage her in conversation; in place of answering a question she repeated it aloud in the same words in which it was put, and even long after she came to answer questions she constantly repeated them once over before giving her reply. At first she had very few words, but she soon acquired a great many, and often strangely misapplied them. She did this, however, for the most part in particular ways; she often, for instance, made one word answer for all others, which were in any way allied to it; thus in place of "tea," she would ask for "juice," and this word she long used for liquids. For a long time also in expressing the qualities of objects, she invariably, where it was possible, used the words denoting the very opposite of what she intended. And thus she would say "white" in place of "black," "hot" for "cold," etc. She would often also talk of her arm when she meant her leg, her eye when she meant her tooth, etc. She now generally uses her words with propriety, although she is sometimes apt to change their terminations, or compose new ones of her own.

She has as yet recognized no person, not even her nearest connections; that is to say, she has no recollection of having seen or known them previously to her illness, though she is aware of having seen them since, and calls them either by their right names or by those of her own giving; but she knows them only as new acquaintances, and has no idea in what relation they stand to herself. She has not seen above a dozen people since her illness, and she looks on these as all that she has ever known.

Among other acquirements she has recovered that of reading; but it was requisite to begin her with the alphabet, as she at first did not know a single letter. She afterward learned to form syllables and small words, and now she reads tolerably well, and has shown herself much interested in several stories previously unknown to her, which she has read since her recovery. The reacquisition of her reading was eventually facilitated by singing the words of familiar songs, from the printed page, while she played on the piano. In learning to write she

began with the most elementary lessons, but made much more rapid progress than a person who had never before been taught. Very soon after the torpor left her, she could sing many of her old songs, and play on the piano-forte with little or no assistance; and she has since continued to practice her music, which now affords her great pleasure and amusement. In singing, she at first generally required to be helped to the first two or three words of a line, and made out the rest apparently from memory. She can play from the music-book several tunes which she had never seen before; and her friends are inclined to think that she now plays and sings fully as well, if not better, than she did previously to her illness. She learned backgammon, which she formerly knew, and several games at cards with very little trouble; and she can now knit worsted, and do several other sorts of work; but with regard to all these acquirements, as already mentioned, it is remarkable that she appears not to have the slightest remembrance of having possessed them before, although it is plain that the process of recovery has been greatly aided by previous knowledge, which, however, she seems unconscious of having ever acquired. When asked how she had learned to play the notes of music from a book, she replied that she could not tell, and only wondered why her questioner could not do the same.

She has once or twice had dreams, which she afterward related to her friends, and she seemed quite aware of the difference between a dream and a reality; indeed, from several casual remarks which she makes of her own accord, it would appear that she possesses many general ideas of a more or less complex nature, which she has had no opportunity of acquiring since her recovery.

In this way she has continued slowly but progressively to improve, and it is now considerably more than two months since she recovered from her sleep. Her bodily health has since then undergone little change: she is still liable to be fatigued by slight exertion, after which she is inclined to sleep; but in this state she never remains long except during the night, when she sleeps like another person. The catamenia have twice appeared, viz., in September and in October, at both times to a greater extent than usual; her bowels still require laxative medicine; but her appetite continues good, and she has evidently gained flesh since her recovery.

Postscript (*March*, 1879).—After a time Mrs. H—— was able to return to her home in England, where she passed the rest of her life happily with her husband, and gave birth to a daughter, who survives her. She was in the habit of corresponding by letter with her friends at a distance, and lived on the most agreeable terms with her immediate neighbors, by whom she was held in much regard on account of her kindly nature and charitable work.—*Brain.*

THE MOLECULAR THEORY.*

By LE ROY C. COOLEY, Ph. D.

THE idea that matter is an aggregate of minute particles, each of which possesses all the essential properties of the mass, is as old as Democritus, but it was left for the present century to crystallize the conception of the atom in clear and accurate expression. The atomic theory, revived and vitalized by the illustrious Dalton, has not simply been able to survive the conflicts in which many an older theory has been wrecked: it has itself been a prime mover of revolutions. It is doubtful whether without it the recent advances in chemical and physical science could have been made.

But the atom in chemistry is not the atom in physics; they are of a different order. When the idea of a chemical atom came to be clearly conceived so that atom could be defined, as it is, to mean the smallest particle of an elementary substance which can enter into the composition of a compound, the most natural, if not, indeed, the inevitable corollary would be that the compound itself must be made up of parts, each of which, containing only the minimum number of its constituent atoms competent to give it character, must be the smallest particle of that substance which can possibly exist. To distinguish this minutest portion of a substance from the chemical atoms of which it is composed, the French called it the *molecule*—literally the little mass; and this word molecule, homeless in the English language less than one hundred years ago, expresses an idea which now lies at the foundation of modern physics.

It has been said that the science of astronomy is the demonstration of the law of gravitation. Indeed, what evidence have we of the truth of Newton's grand generalization, except that it explains the phenomena of the skies? So, in the outset, we may say that the science of physics is the demonstration of the molecular theory of the constitution of matter, since it explains phenomena, suggests research, directs experiment, classifies and unitizes wide ranges of apparently diverse results, to an extent unparalleled by any other.

This theory boldly affirms a limit to the divisibility of matter, and thus seems to defy the logic of the metaphysician, who, passing the limit set by the necessary imperfections of manipulation, carries the process of subdivision mentally downward through the scale of littleness, until, finding no place where his conception of subdivision must halt, declares that no limit exists. But the physicist does not deny the logic of the metaphysician; he simply remembers that mental conceptions need not of necessity represent the realities of nature's processes,

* Read before the Poughkeepsie Society of Natural Science, December, 1878.

in the subdivision of matter. He claims that the line which may be mentally thrust through the minutest particle of matter is not a needle nor a knife—that it is the mathematician's line as immaterial as space —and that the thrusting of such a line can accomplish no division. He claims that, applicable as it may be to space, such logic need not bind the physicist who studies the constitution of bodies which inhabit space.

Therefore, unconcerned about the abstract question of divisibility, the physicist anxiously inquires whether the phenomena of the material world can afford any testimony in regard to the ultimate constitution of bodies. And the molecular theory may be regarded as an induction from a multitude of observed facts—a generalization reached by a careful comparison of many established principles. The object of the present paper is to present the theory in this light. To exhaust the evidence, however, by this method would be to present the science of modern physics complete, a task impossible at a single sitting.

The three fundamental conceptions embodied in the molecular theory are : the existence of molecules, the existence of molecular spaces, and the existence of molecular motions.

Now, there may be phenomena which declare the existence of molecules without touching the question of molecular space or of molecular motion, and proofs both of the existence of molecules and of molecular spaces may be altogether silent on the question of rest or motion. But notice : whatever evidence we have of the existence of intervals between the ultimate parts of a body is equally evidence of the existence of molecules, and whatever phenomena indicate the existence of motion among these interior parts of a body do equally affirm the existence both of molecules and of molecular spaces. If, then, the three classes of phenomena be presented as bearing first upon the molecule, second upon molecular spaces, and third upon molecular motion, the testimony will be continuous and cumulative.

First, then, as to the existence of molecules. We will confine our attention to two sources of evidence—the phenomena of divisibility and of chemical synthesis.

Is it possible, by continued subdivision, to reach a particle the division of which would put an end to the existence of the substance—not in the sense of annihilation, but, in other words, to reach a particle whose division compels a substance to suffer death by yielding up those identifying properties by which alone we distinguish it from other kinds of matter?

A piece of marble may be crushed and reduced to an almost impalpable powder, and yet, on examination, each little grain is found to be an angular block of stone, lacking no property of the original block except its size and form. The same may be said of other solids. Even ice, keep its temperature low enough, may be reduced to microscopic fineness, and each little particle, notwithstanding its minuteness,

will be a block of ice. Nay, more; when by such mechanical means subdivision can be carried no further, we may resort to a gentle heat and find these microscopic blocks crumbling into fragments finer still; for what is melting but a process of division? In it, particles simply fall apart because the ties of cohesion are sundered by the heat, and the liquid is the same substance, differing from the impalpable powder only in the mobility due to its finer state of division. Now touch the liquid with a somewhat intenser heat. We find that the water is converted into steam, becoming invisible, and that the water-gas occupies a volume seventeen hundred times larger than did the water which it represents. However remarkable this change, yĕt it does not touch that which gives character to the substance. In all its essential properties it is water still. Furthermore, not the slightest addition or subtraction has been made. The process, in all its steps, from the original block of ice to the seventeen-hundred-fold volume of invisible vapor, is simply a process of division.

Now endeavor to carry the subdivision further. It may be that a fiercer heat will be a keener edge to cleave the invisible particles of water-gas. Thanks to Professor Chandler, who has taught us how to apply the requisite heat without at the time introducing a chemical attraction, so that we may be left confident that, whatever the result, it is accomplished by the same agents by which our previous subdivisions have been made.

In this experiment the steam is passed into a platinum flask, which is kept red-hot. From this flask a delivery tube conveys it to a jar designed to receive the products of the experiment. The invisible steam enters the platinum flask; an invisible gas also passes onward to be caught in the receiver; but afterward, on bringing a flame to the mouth of this receiver, an explosion declares that its contents are water-gas no longer—that a mixture of hydrogen and oxygen has taken its place. The steam particles are evidently broken by the heat. But mark the result: the fragments are no longer particles of water. The red heat has dissected the steam particles, and revealed the fact that they consist of still smaller pieces of hydrogen and oxygen.

In the form of steam, therefore, water is in its finest possible state of division, for to divide it further is to compel it to cease to exist as water. We are therefore entitled to declare that this substance consists of ultimate particles, which can not be divided without changing them into other kinds of matter. These are its *molecules*. Next, in the light of chemical synthesis, also, we may see the existence of these ultimate particles.

Hydrogen and oxygen are the inevitable constituents of water, and two volumes of hydrogen to one volume of oxygen are the invariable proportions. No human agency can obtain water by combining any other elements, nor by combining these in any other proportions.

These are facts confirmed by all experience. Nevertheless, it mat-

ters not how little oxygen is taken, provided only that the proper proportion of hydrogen is supplied. Then let us conceive the least possible portion of oxygen. Let the mind wrestle with the conception and reduce the volume of this gas until it is fixed at the smallest that can take part in a chemical action. Then conceive it combined with a volume of hydrogen twice as great. We may contemplate the infinitesimal droplet of water so produced, but to conceive a droplet any smaller is impossible, since this one contains no more than the least possible portions of its elements. To break this droplet of water would be to reduce it to fragments of hydrogen and oxygen. Again, then, do we find our minds in the presence of particles which can not be divided except at the sacrifice of their identity—in other words, in the presence of *molecules*.

But if molecules exist, the second question at once arises, Are they so closely packed as to constitute a continuous mass, or are they separated by intervening spaces?

A second class of phenomena directs our judgment here. We might detail the mathematical investigation by Cauchy, a third of a century ago, by which he demonstrated the impossibility of the dispersion of light in a substance whose minutest parts are absolutely homogeneous. It was proved that dispersion happens only on condition that "two contiguous portions of the medium, whose dimensions are moderately small fractions of a wave-length of light, are dissimilar." The molecules with intervening spaces would realize such dissimilarity.

But, confining ourselves to the experimental side of the problem, we find a variety of familiar phenomena ready to bear witness to this structure. Among them are porosity, expansion and change of physical condition, and the diffusion of vapors.

In regard to porosity, an old and homely experiment will give us a starting-point. We take a tall and narrow glass jar and fill it so completely with alcohol that the addition of a single drop will endanger an overflow. The jar appears to be full of a perfectly homogeneous liquor. But if a sheet of cotton wool, whose fibers have been previously well loosened, be at hand, fragment after fragment may, with care, be slowly introduced, without causing the overflow of a single drop, until the jar appears to be filled with moistened cotton instead of with alcohol. We have before us the surprising appearance of two bodies filling the same space at the same moment. Surely, however, we are not at liberty to adopt this explanation. For what should we call that which has no power to exclude another from the space which it occupies? To call it matter is to obliterate all distinction between matter and space. We are impelled to seek another explanation, and we find one more acceptable in the hypothesis that neither of the two bodies wholly fills the space which it appears to occupy—that spaces, too minute for even microscopic vision to detect, intervene between the ultimate particles of both, and to such an extent that these mate-

rial particles of each find a habitation in the spaces of the other. Moreover, this experiment is but one of a large class, which all alike present the appearance of two or more bodies existing at the same time in the same place. And this phenomenon is a symbol which, translated, declares the existence of intervening spaces between the ultimate parts of which bodies of matter are composed. In regard to expansion and change of form, one of the most familiar and universal effects is the expansion of bodies by heat, and the most obvious classification of material objects is into three physical forms—the solid, the liquid, and the gaseous. We have only to admit the existence of molecules and of molecular spaces, and expansion can be defined at once to be the enlargement of these spaces under the influence of a force which drives the molecules asunder. Moreover, since distance is known to control the influence of attraction, it is plain that the melting of a solid and the vaporization of a liquid would be the necessary consequences of increasing the molecular distances, until cohesion is, in the one case nearly, and in the second case altogether, overcome. The existence of matter in three physical forms, and its changes from one to another under the influence of varying temperature, here find a most happy explanation.

But there follows a most important inference. If the gaseous form of matter is due to the separation of its molecules, then how enormously must their distances asunder exceed the diameters of the molecules themselves! For example, a cubic inch of water becomes about seventeen hundred cubic inches of steam. If this increase of volume is due to the enlargement of molecular spaces, how small a fraction of the vapor volume can consist of the material molecules! Can any experiment be brought to our relief, and furnish any solid ground on which we may stand and check the theory by testing the truth of this consequence? In "The New Chemistry,"* its author gives the following elegant description of an experiment on the diffusion of vapors:

"We have here a glass globe, provided with the necessary mountings—a stopcock, a pressure-gauge, and a thermometer, and which we will assume has a capacity of one cubic foot.

"Into this globe we will first pour one cubic inch of water, and in order to reduce the conditions to the simplest possible, we will connect the globe with our air-pumps and exhaust the air, although, as it will soon appear, this is not necessary for the success of our experiment. Exposing next the globe to the temperature of boiling water, the liquid will evaporate, and we shall have our vessel filled with ordinary steam. If, now, that cubic foot of space is really packed close with the material which we call water—if there is no break in the continuity of the aqueous mass, we should expect that the vapor would fill the space to the exclusion of everything else, or at least would fill it with a certain

* By J. P. Cooke, Jr., "International Scientific Series," D. Appleton & Co.

degree of energy which must be overcome before any other vapor could be forced in. Now what is the case? The stopcock of the globe is so arranged that we can introduce into it an additional quantity of any liquid on which we desire to experiment without otherwise opening the vessel. If, then, by this means, we add more water, the additional quantity will not evaporate, provided the temperature be kept at the boiling-point. Let us next, however, add a quantity of alcohol, and what do we find? Why, not only that this immediately evaporates, but we find that just as much alcohol-vapor will be formed as if no steam were present. The presence of the steam does not interfere in the least degree with the expansion of liquid alcohol into alcohol-vapor. The only difference which we observe is that the alcohol expands more slowly into the aqueous vapor than it would into a vacuum. If, now that the globe is filled with aqueous vapor and alcohol-vapor at the same time, each acting in all respects as if it occupied the space alone, we add a quantity of ether, we shall have the same phenomena repeated. The ether will expand and fill the space with its vapor, and the globe will hold just as much ether-vapor as if neither of the other two were present; and so we might go on, as far as we know, indefinitely. There is not here a chemical union between the several vapors, and we can not in any sense regard the space as filled with a compound of the three. It contains all three at the same time, each acting as if it were the sole occupant of the space."

Now these experimental results find an explanation nowhere else but in the inference, previously made, that molecular spaces do exist, and that they are so relatively large that the molecules of each gas find, in the spaces between the particles of all the others, abundant room to manifest all their characters.

If, now, we turn from vapors to the examination of permanent gases, we find a kindred action. Moreover, it is an action which not only confirms our evidence of the existence of molecules and molecular spaces, but, as we shall see in the sequel, in addition thereto suggests an answer to this important question in the history of molecules—are they in motion or at rest?

Hydrogen gas is sixteen times lighter than oxygen. Let us bring the open mouth of an inverted jar filled with hydrogen down upon the open mouth of a similar jar filled with oxygen. By this means we obtain a single cylinder of gas, the lower half of which consists of the heavier oxygen, and the upper half of the lighter hydrogen, the two gases being in contact only at their surfaces in the middle of the column. Their relative weights would lead us to expect them to maintain these positions; but the well-known properties of these gases enable us to learn that they do not. Neither one alone is explosive; their mixture is. Now, after a time, if we separate the jars and bring a flame to the mouth of the lower one, and then to the mouth of the upper one, two successive explosions occur, declaring that both jars

contain a mixture of the gases. What must have happened? Evidently a portion of the heavier gas has risen into the upper jar, and a portion of the lighter gas has fallen into the lower jar, and this too, notwithstanding the fact that their difference in weight is more than a third greater than that of lead and water. A further study of this phenomenon reveals the significant fact that just as much of each gas diffuses into the space of the other as would expand into a vacuum of the same size. In fact each gas is, at all temperatures, a vacuum to every other. This fact remains an unsolved mystery, except we admit the existence of molecules and of molecular spaces far outmeasuring the molecules themselves.

Vapors and permanent gases are, therefore, not unlike in this respect. But when we compare this diffusion of the latter with the production and commingling of the former, as shown in the globe experiment, we discover this difference: whereas the molecules of the vapor are driven into mixture by the application of heat, those of the permanent gases spring spontaneously each into the spaces of the other without it. Plainly there exists among the molecules of the gases at low temperature an energy to drive them asunder, such as must be introduced by artificial means among those of vapors to enable them to manifest the same action in the same degree. We need to say, "in the same degree," for even liquids do spring into the gaseous form and mingle their vapors with other gases at common temperatures. This is evaporation. And when we remember, further, that many solids, notably ice, camphor, iodine, yield vapors to the atmosphere on similar exposure thereto, we can feel justified in saying that there exists in gaseous and liquid and solid bodies alike an energy by which their molecules are urged asunder.

This molecular energy bears the closest relationship to heat. Of this the facts already stated are sufficient evidence. Every variation in one is accompanied by a corresponding variation in the other. Whenever heat is expended this molecular energy in the body receiving it is increased. Whenever a body of gas, freed from opposing pressures, expands, in obedience to this molecular agency, its own temperature is reduced. Moreover, the most exact quantitative relation can be traced. This molecular energy and heat are, therefore, correlative. All this is suggested by the facts of expansion, vaporization, and diffusion. But I have no time to give even an outline of the classic researches of Rumford, Mayer, Joule, and others, which prove that heat and molecular energy is the energy of molecules in motion.

Molecules, molecular space, and molecular motions—these three conceptions stand as the modern translation of the symbols on which the facts in regard to the constitution of matter are written. According to the theory, in every material body these three fundamental elements are embodied. It consists of particles which can not be divided without changing the nature of the substance, separated by distances in

comparison with which their own diameters are sometimes as insignificant as are the diameters of planets in comparison with their immense solar distances, and finally in motion, inconceivably rapid, and never ceasing. Such is the molecular theory of matter, in its most general form of expression. And in this form it seems destined to do for the science of physics what has been done for chemistry by the atomic theory, and for astronomy by the theory of gravitation. It seems competent to bring all branches into harmonious relation as constituents of a single science. It may do this even if the mathematical measurements of the magnitudes it describes should prove to be beyond the reach of human skill.

But, if molecules exist, what are their masses and their diameters? If they are not in contact, what isthe measure of their separation; and, if in motion, with what velocity? These are legitimate subjects of research suggested by the theory itself, and no less important in the science of physics than the problems of astronomical magnitudes are in astronomy. It is, therefore, not strange that the best intellects among experimental and mathematical philosophers should be found bending their energies toward the solution of these problems. Already very wonderful progress has been made, and numerical values are assigned to these molecular magnitudes, in some cases with great confidence in their accuracy, and in other cases provisionally, awaiting better and more extended means of research. For example, Dr. Joule tells us that the hydrogen molecule is darting through the molecular spaces of this gas at the rate of 6,099 feet a second; and Clerk Maxwell, that the molecules of oxygen move at the more sluggish rate of about 1,525 feet a second. We are further informed that the distance from center to center of the molecules of a gas is probably about $\frac{1}{800000}$ of an inch. Different methods of investigation agree tolerably well in pointing to $\frac{1}{30000000}$ of a millimetre as a fair approximation toward the diameter of a molecule—that is to say, about 760,000,000 of these bodies lying side by side would bridge the space of a single inch.

These magnitudes are of an order which only modern science has ever asked the intellect of man to contemplate. The human mind thus discovers its position between two infinities. It is able, through the agency of the senses, to acquaint itself directly with a very limited range of phenomena, but, planting itself upon this little fragment of solid ground, it reaches into space, and by observations and by computations made upon them becomes acquainted with the infinitely great; while in the other direction it pierces the recesses of minute bodies, and by observations and computations there it becomes acquainted with the infinitesimal. The results attained in both directions are alike incomprehensible. Who can, for example, accurately conceive the distance described as 1,000,000 miles? Even he who has made the circuit of the world can not rely on this extended experience to enable him to see the beginning, middle, and end of 1,000,000 miles in

their true proportions. Yet this is a little more than the one-hundredth part of our distance from the sun, from which we get the light and heat on which our lives depend. What, then, shall we say of those sidereal spaces to measure which this solar distance is taken as the unit! The astronomer contemplates magnitudes and distances and motions expressed by figures of such vast array, that the power of enumeration is almost staggered, and our capacity to comprehend values is altogether overwhelmed by them. But let us reduce the unit of measure from the mile to the inch, and then let us take the reciprocals of these enormous values obtained by the astronomer in his study of the planetary composition of the universe, and we shall have before us the order of measurements which engage the attention of the physicist who studies the molecular composition of matter. If we are not dismayed by the one, let us not be by the other. In one case our conceptions are pictures in miniature; in the other they must be pictures enlarged. But it is no more difficult to picture the distance between two minute bodies, when measured by the hundred-millionths of an inch, than it is to picture it between two greater ones when measured by the hundred millions of miles. To comprehend the real magnitude is, in both cases, impossible, and our belief in the existence of either must depend on our faith in the infallibility of mathematical processes and on the observations upon which they are based. But granting the existence of such evidence to sustain it, neither can be called incredible, however it may transcend our comprehension, for credulity consists, not in believing, but believing without evidence.

NEUTER INSECTS.

By PHILIP WOOLF, M. D.

HOW the workers of many insects became sterile is an interesting question, though one difficult to answer. Those who believe in special creation solve this problem, as they solve so many other difficulties, by stating that insects are sterile because they were created sterile. The majority of educated persons, however, require to be convinced by some more tangible argument; the conclusion that things are because they are, having lost the only merit it ever possessed, the annihilation of thought.

To state the problem that all may understand it: there are many insects, as the bees, ants, wasps, and termites, that are divided into three castes, males, females, and workers; the latter are sterile, and it is asked how, according to modern theory, these workers can have arisen? It is said that, since they do not propagate their kind, no spontaneous variations can be produced for natural selection to work

on, and hence that there is no other explanation of their existence than that they are specially created—that is, created in opposition to law.

To simplify the initial inquiry, we will suppose that workers differ from females only in that they are not fertile, the secondary differences being reserved for discussion toward the end of this paper.

That a creature may develop, it is essential that it be supplied with a sufficiency of food. Even with human beings food is all-important; if with these a sufficiency of mineral ingredients be not assimilated, we have the disease called *rickets;* insufficiency of vegetable food will cause scurvy; insufficient nutriment dwarfs the body and mind generally. The growing body must have enough material out of which to elaborate tissue, or the tissue, muscle, nerve, bone, can not develop. Now let it be supposed there are two larvæ or grubs of the bee, which under similar conditions will reach similar degrees of development; further suppose that one larva, which may be called A, receives an over-abundance of food, while the other larva, which may be called B, receives a quantity of food just sufficient for its more important wants, what will happen? The larva A will reach its full development—it will be a queen-bee; the larva B, on the other hand, not having food enough for all its wants, and furthermore having within a given time to change its conditions, it must use the nutriment for the building up of its more important organs, must work it up into tissues and structures that are essential to all bees. Its head, body, legs, and wings must be perfected before its reproductive system; the individual must profit before the race; and, if the food is only sufficient for individual functions, the race functions must suffer, the reproductive system must remain in an incipient state.

This conclusion is no mere theory, for among the higher animals, and even with man himself, insufficient nourishment first produces its effects on the reproductive system. Loss of blood induces abortion; badly prepared or insufficient food decreases or entirely checks the production of offspring. The distinction first clearly formulated by Dr. Carpenter is now a commonplace of science: "There is a certain degree of antagonism between the nutritive and reproductive functions, the one being executed at the expense of the other. The reproductive apparatus derives the materials of its operations through the nutritive system, and is entirely dependent on it for the continuance of its functions. It may be universally observed that, when the nutritive functions are particularly active in supporting the *individual*, the reproductive system is in a corresponding degree undeveloped, and *vice versa*."

With bees the effects produced by food are clearly shown: a larva which otherwise would turn into a neuter is supplied with a different kind of food and it is converted into a queen. Huber obtained queen-bees by placing some of the "royal food" in cells inhabited by the larvæ of workers. Kleine performed the same experiment, placed a portion

of the royal food on the inner margin of the worker cell and produced queens. With bees, then, we see that the neuter is only a female with the reproductive organs partially developed, a conclusion further enforced by the fact that the neuter sometimes even lays eggs which develop into the drone or male bee. In this case then, at least, it may be said that the fecundity or sterility of bees depends *almost* entirely on the nature of the food given to the larvæ. With the true ants also, the so-called neuter is only a partially developed female, although there are no recorded observations to show that the difference between the fertile and the infertile insect is due to difference in food.

To advance now a step further: insects, originally, were either male or female; there were no neuters. For reasons presently to be given, we conclude that the males of even social insects, in addition to the duty of fecundating the female, also undertook the duty of defending the nest against warlike intruders. It may be also safely concluded that originally the females of even social insects, in addition to the duties of maternity, also undertook the labors of building the nest and taking care of the young—customs that still prevail more or less with many insects. Thus, the females of the solitary bees, after impregnation, hybernate during the winter. With the warm days of spring they awaken, build their nests, and die. Among wasps a similar state of things obtains. When the winter approaches, the entire colony, with the exception of a few pregnant females, dies. In the spring these females begin building a new nest, laying eggs, and so producing an efficient corps of assistants to aid them in their future labors.

Supposing, then, that originally the females undertook most of the work now done by the neuters; supposing, also, that at the beginning of spring there are only a few females, or even one female, to commence the work of building the nest and feeding the future progeny. With many duties to perform, it is not unwarranted to conclude that some duties may not be completely performed. The immediate success of the colony depends, not so much on the number of males or of females, as on a body of efficient assistants. Now, when one or a few insects have to feed many, some of the larvæ receive an abundance, some barely a sufficiency of food; and, on the theory previously advanced, we may see how neuter insects arose. The fact that quality as well as quantity of food is essential to future fertility does not add to the difficulty, since, as it takes more time to produce the highly nutritious than the somewhat less nutritious food, the conditions are still the same. If efficient assistants could be produced at a less expenditure of labor and in a shorter time than females, a supposition countenanced by facts, natural selection begins to work. In a given neighborhood those insects which produce a corps of assistants soonest, and with least expenditure of labor, will stand a better chance of obtaining food—of surviving—than those insects which give the same amount

of attention to each larva, rearing them all into perfect insects—a benefit also accruing to the earlier hatched larvæ themselves, as they sooner reach maturity, and can thus obtain an abundance of food without rivalry. These earlier produced neuters have their reproductive systems only slightly less developed than egg-bearing insects ; but natural selection, acting on the *nurse*, will cause them to grow less and less. Reproductive organs that do not produce are of no use to their possessors ; and, as this slightly less developed but useless reproductive system would require more attention and more food from the fertile nurse than would those larvæ in which it was a mere rudiment, natural selection, by working on the instinct of the nurses, would modify, alter, or even suppress what was of no use. Or we may suppose that in the distribution of food to the larvæ the action is direct, some receiving such a minimum quantity of food that the reproductive organs remain rudimentary from want of material to build them up.

The necessity of producing offspring quickly in early spring would give rise to the instinct to feed the first produced brood of larvæ on food insufficient in quality, or in quantity, or in both. The eggs, then, first laid by the female would develop into neuters. Neuters being sterile females, they would inherit the instincts of true females when they in turn took charge of the young. Whatever may be the worth of this theory, it throws some light on the curious fact that with some insects, as the bees and ants, the sexes are produced at different times. With bees the queen first lays eggs which produce neuters ; then, at a later period, eggs producing males. According to Gould, the female of the *Formica sanguinea*—the red ant—lays eggs which will produce females, males, and workers at three different periods. That the habit is so is well known ; but on the theory here supported can not we see how the habit arose, and the reason why such a habit exists ?

Thus far food alone has been supposed to affect the development of insects, but there are several secondary factors ; size of cell being one. Thus with the bee, the cell in which the queen is hatched is larger, differently formed, and in weight said to be equivalent to one hundred ordinary cells ; the cells from which emerge the males are also larger than the cells of neuters. Now, the extra labor necessary to produce these cells in founding a new colony, the extra labor in attending to the inmates, and the non-necessity of having males or females at this early stage of colonial existence, are other reasons why the first-laid eggs produce only neuters. At present and in this place these points can be only touched on ; in the future they will receive more elaboration.

If neuters have arisen in the manner suggested, how has their inflexibility of character been maintained ? By natural selection modifying the instincts of the *nurse*. What at first arose through the incapability of one or several insects taking care of many insects, became through the action of natural selection, by the survival of those

insects which produced a given result with least labor to themselves, an established instinct. Further questions may be now asked: Why is it that any other insects besides neuters have been produced? As they can not propagate their kind, how have they become gifted with the instincts to take care of and to feed the young, provide food for the colony, build nests, etc.?

To the first question a sufficient reply is, that, if nothing but neuters were produced, there would be no insects. The other questions may be answered by an amplification of a statement already made. Neuters, as a rule, are sterile females; the exceptions to this will be considered further on; they inherit the instinct of females and perform their duties with the one exception of ovulation. To give a few details: Originally there were no neuters; and as females were numerous, each female would lay comparatively few eggs. How the neuters arose we have already seen; at first they were few, gradually increasing until they equaled and finally outnumbered the females. At the same time the labors of the female became more restricted; as they decreased in number they must, in order to keep up the colony, lay more eggs: as a result, the extra time devoted to ovulation was so much time taken from cell-building, nursing, etc. Applying this theory to facts, we can see why with the increase of neuters the duties of the queen-bee have grown less and less until they consist of nothing but ovulation. The queen-bee is a queen only in name, receiving just such extra care that her time may be entirely devoted to propagating the species. At such time when each hive only contained one reigning queen, this female had to assume the reproductive functions of her twenty thousand sterile sisters, and it is not strange that she has no time to build or to feed the young. Under no other conditions could she lay her two thousand to three thousand eggs a day. The case of the termites or so-called white ants is more striking, the female laying eighty thousand eggs in the course of a day, or very nearly one egg a second continuously. What other duties can this huge animated egg-sac perform?

With existing social insects, as a rule, the male does little or no work but that of fertilizing the females, but before the appearance of neuters we may suppose he had other duties. With many beetles the male performs a large share of the labor; the male of the burying beetle, for example, excavating the grave in which its prey is buried and in which the female deposits her eggs. With many insects the male defends the nest or burrow from the attacks of invaders, of which take an example quoted by Mr. Darwin in his "Descent of Man": "The two sexes of *Lethrus cephalotes* (one of the Lamellicorns) inhabit the same burrow. If during the breeding season a strange male attempts to enter the burrow, he is attacked; the female does not remain passive, but closes the mouth of the burrow and encourages her mate by continually pushing him from behind." That males are not always

passive, the work just quoted abundantly proves. Now when neuters are produced from males their duties differ from the neuters produced from females, and, as we have supposed that the duties now performed by sterile females were once performed by fertile females, so we may now conclude that the duties performed by sterile males were once performed by the perfect males. The worth of this conclusion will be presently seen.

The remaining difficulty is to account for the fact that with many insects the neuters differ considerably from the fertile insects. Thus, for example, with the termites or white ants; these are the perfect males and females, the soldiers, which are aborted males, and the workers, which are aborted females. The males and females have wings, the neuters are wingless; the workers undertake architectural duties, act the part of nurses, etc., while the soldiers defend the nest from attacks. Both workers and soldiers are blind, but whereas the workers have a somewhat circular head and small jaws, the soldiers have a comparatively enormous head, and strong resisting mandibles. In what manner then, or through what cause, could the head of this soldier termite differ so greatly from either that of the perfect male or perfect female? Or, since it is impossible in any given case to explain all the details satisfactorily, let it be asked how it is that so many neuter insects differ from their parents.

Neuters are either sterile males or sterile females, and in many cases do not differ greatly from their fertile progenitors; the social bees and wasps are examples of this. On the theory advanced, it has been supposed that originally the neuter differed only from the perfect insect in that it had a rudimentary reproductive system. Now, suppose, to take an imaginary example, that in a colony of ants there are only males and females; that the duty of the male is the defense of the nest against encroaching enemies, and that the duties of the females are to build the nest, lay eggs, and take charge of the young. Of course the males and females having different duties to perform will have their structures differently modified; say, in our case, the male has a largely developed head like the soldier-termite, the female a head like the worker-termite. Going a step further, neuters begin to appear, the aborted male still performing soldier duty, the aborted female still attending to its domestic duties. The neuters continuing to increase as we know they have increased, and the true males and females decreasing in number as we know they have decreased, a state of affairs is reached in which it is essential to the welfare of the colony that the male should confine himself to fertilizing the female, the female principally confine herself to laying eggs.

Thus far, the fertile and infertile males, the fertile and infertile females, have resembled each other; but disuse of parts induces retrograde metamorphosis, or modification or suppression of useless parts. If the males no longer use their heads and jaws to protect the com-

munity, these parts would decrease in size; if the females no longer assist in building, if their entire duty is to lay eggs, their wings, legs, jaws, etc., will decrease; the surplus of force thus entailed being added to the reproductive system. Thus, then, there would have been produced the four castes found among the termites; the soldier representing the typical male of the species, the workers the typical females minus the perfected reproductive organs. But—and here is the great difficulty—how can the changed male have given his lost organs to his sex, and the female have transmitted her original but now modified peculiarities to the workers; especially as neuters do not propagate, and hence can not transmit their characters to progeny? Another law solves a portion of the difficulty: peculiarities acquired at any period of life are apt to appear in the same sex at the same time of life. Disuse having wrought its changes on our fertile insects after they had reached their perfect form, we can not expect them to appear in offspring which never reach this form. The modifications of structure were produced that the reproductive system might be benefited; why, then, should they take place in those insects which have a rudimentary and hence useless reproductive system?

We have now to ask whether those larvæ which are to produce fertile insects resemble, in any stage of their existence, the larvæ which are to produce neuters; whether, for example, the fertile male termite resembles, at any time, the infertile soldier. The reply to this is partly positive, partly negative; the larva of the female termite resembles very nearly the larva of the worker; but there is no great resemblance between the male and the soldier larvæ; there is a greater resemblance between the pupæ.

The fact alone that the female of social bees, and the male and female of white ants, should be presented under two forms is no novelty in insect history. In the aphides or plant-lice a similar state of affairs obtains: there is the perfect and imperfect female. Even as high in the scale as butterflies dimorphism is not uncommon. Mr. Wallace has discovered two forms of the female of *Papilio Memnon*, an inhabitant of the East Indies, one of which has tailed wings, the other of which is tailless. Several butterflies have three kinds of females, or are trimorphic. Hence the mere differences between neuter and perfect insects are nothing unusual, considered as differences. Were the workers fertile and thus able to propagate their peculiarities, the difficulties would vanish; but the problem why a fertile female should give birth to two or three distinct forms is still shrouded by mysteries, accept what explanation we may.

Our alternative that the workers are the type from which the males and the females have diverged is only an hypothesis, but in view of the facts it is the only alternative left us; since the neuters themselves can not have diverged from any type on account of their sterility.

The conclusions, then, reached in this paper are, that in many cases the differences between fertile and infertile insects are due to the quality or quantity, or both, of the food given to the larvæ. This conclusion is of worth, since it is supported by Huber, Smith, Woodbury, and others; though these naturalists only apply it to the social bees. The suggestion of Professor Wyman, that the difference in development is due to the difference in the time the eggs are laid after fertilization, seems to be opposed to facts; especially to the experiment of Kleine, who reared worker-larvæ into queens by feeding them on royal food. The other conclusion is, that the neuters represent the type from which the true males and females have diverged; that in those cases where food is powerless, the neuter retains its immutability for the reason that its development is arrested at a certain stage; that is, it does not go beyond the state reached by the typical progenitor, while the perfect males and females go beyond this stage, and that the differences between them and the neuters were inaugurated at this time; that changed conditions have been potent in producing such differences; that the differences are only inherited at that advanced period of progression in which they were initiated. In other words, to render this conclusion plain to the general reader, we believe that if the neuter-worker of the white ant, for example, were to progress in development, it would turn into the fertile female; if the neuter soldier of the white ant were to continue on the line of development, it would become a fertile male. This does not give support to the theory that the worker and soldier are immature male and female; that they are the perpetual babies, while the perfect insects are adults—since we believe that in their way the neuters are as adult as their parents. This proposition may be rendered clearer by a symbol, which may be represented by the letter Y. The stem of this letter will stand for the typical insect represented at the present day by the neuter, and the two arms, respectively, will represent the male and the female, which, after the typical insect reached a stable form, diverged into new routes of progression.

At some future time we hope to work out this subject more elaborately, and, from the observations and facts already collected, it is believed that the theory can be defended if not vindicated. Our present purpose, however, has been accomplished—to introduce to the general reader a subject which has perplexed, and still perplexes, our greatest naturalists.

AGNOSTICISM AS DEVELOPED IN HUXLEY'S HUME.*

By JAMES McCOSH, LL. D.,
PRESIDENT OF PRINCETON COLLEGE.

PROFESSOR HUXLEY is a man of strong intellectual tastes and tendencies. He is evidently an enthusiast in his biological studies. It is not so generally known that he is also a metaphysician. This he has shown in his published address on Descartes and in other papers. He has now come forward to defend the study. (See "Popular Science Monthly," May, 1879.) Kant has made the remark that we can not do without metaphysics, and others have noticed that those who affect to discard them will commonly be found proceeding, without their being aware of it, upon a very wretched metaphysic. The Professor now tells us, "In truth, to attempt to nourish the human intellect upon a diet which contains no metaphysics is about as hopeful as that of certain Eastern sages to nourish their bodies without destroying life." He adds: "By way of escape from the metaphysical will-o'-the-wisps generated in the marshes of literature and theology, the serious student is sometimes bidden to betake himself to the solid ground of physical science. But the fish of immortal memory who threw himself out of the frying-pan into the fire was not more ill advised than the man who seeks sanctuary from philosophical persecution within the walls of the observatory or of the laboratory." He shows that such conceptions as "atoms," and "forces," and as "energy," "vacuum," and "plenum," all carry us, whether we will or no, beyond a physical to a metaphysical sphere.

I rather think that the Professor's metaphysics were derived primarily from David Hartley, but especially from James Mill, reckoned an age or two ago, in England, the chief philosophical authorities by those not trained at the two English universities. Hartley connected metaphysics with physiology; and James Mill, after abandoning the trade of a preacher, adopted the fundamental principles of David Hume, and transmitted them to his son John Stuart Mill, who modified and improved them by independent thought and a larger acquaintance with other systems. Professor Huxley has now, in this work on Hume, given his own philosophy, which is substantially that of Hume and James Mill, with some not very valuable suggestions from Bain, and a criticism now and then derived from Descartes and Kant, of whose profounder principles he has in the mean while no appreciation. It is expounded in the form of an epitome of the system of the Scottish scepter with constantly interspersed criticisms of his own. His style

* "Hume," by Professor Huxley.

is not that usually supposed to be philosophic : it is not calm or serene or dignified ; but it clearly expresses his meaning, and it is graphic, living, and leaping. He shows everywhere great acuteness, and the shrewdness of one who is not to be taken in by show and pretension, or awed by authority. No man is quicker in starting an objection, which, however, may be of a surface character, and not penetrating into the heart of the subject. I can not discover in his speculations the calmness of one who is waiting for light, or the comprehension of one who goes round the object examined and views it on all sides.

Mr. Darwin has elected and proclaimed Professor Huxley as the philosopher of his school, and this when many would place Herbert Spencer above him. I treat and criticise him as such. Most of the members of the school are not professed metaphysicians; but, like the man in the French play who spoke prose all his life without knowing it, there is a metaphysic underlying their reasonings ; and this metaphysic, without their being aware, is very much that of Mr. Huxley. I venture not to urge objections to his biology, of which he is a master, and to be reviewed only by a master in his department. But he is not so formidable as a metaphysician, and one with but a sling and stone may cast him down, and the philosophy of his admiring host, by a few facts as clearly revealed to our inner consciousness as the facts of physiology are to the external senses.

I am in this paper to develop first, one by one, the positions of Hume, then the modifications of these by Huxley. In proceeding, I will show how the negative positions of both are to be met. In the close, I will show what kind of knowledge agnosticism admits and what it denies, and estimate the influence it is likely to exercise upon the present age, and especially upon young men liable to be drawn into its vortex :

1. According to Hume, what is commonly called mind starts with *Impressions.* This is a very misleading term. Taken literally, it implies three things : a thing impressing, say a seal; a thing capable of receiving an impression, say wax; and a figure, say of a head, impressed. Applied, it ought to denote an external thing ready to impress itself, a mind to be impressed, and an impression, say a perception, made upon it. The language is unfortunate ; but, carrying out the similitude, we might have a psychology containing much truth : a thing perceived, a perceiving mind, and a perception. But according to Hume, followed by Huxley, we have none of these things. We have in our exercise of what are commonly called the senses no perception of anything, no mind to perceive, and no object to be perceived. We have simply a succession of passing states, and these states of nothing permanent.

This is the avowed doctrine of Hume. Huxley adopts it. He amends it by classifying the IMPRESSIONS into—A. Sensations ; B. Pleasure and Pain ; and C. Relations. Let us confine our attention for the present to the first two, to Impressions, A. Of Sensation, and B.

Of Pleasure and Pain. Let us notice what we have got, as he describes it: "When a red light flashes across the field of vision, there arises in the mind an impression of sensation which we call red. It appears to me that this sensation red is something which may exist altogether independently of any other impression or idea as an individual existence. . . . The whole content of consciousness might be that impression." These Impressions, with the Pleasure and Pain, are represented by him as knowledge; this without a thing knowing or a thing known. It is such knowledge with which man starts, such knowledge as man can attain, and the foundation of all other knowledge.

He has already laid the foundation of agnostics. He has started with an assumed principle, from which only nescience can follow. These impressions can never by logic or any legitimate process give us the knowledge of things. The addition or multiplication of 0 can give us only 0; so the additions or multiplications of impressions, of sensations, of pleasures and pains, can give us only impressions in sensations and in pleasures and pains.

Now, all this is to be met by showing that the mind begins in sense-perception with the knowledge of things. It knows this stone as an existing and resisting object. It knows self as perceiving this object. "The whole content of consciousness" never is a mere impression, say a sensation of red. It is of a thing impressed. If I am asked for my proof, I answer that all this is contained in my very consciousness. I have, in fact, the same evidence of this as I have of the existence of the impression "red." I am conscious of self perceiving a red object. Indeed, any impression I may have is an abstraction taken from the self impressed.

2. Omitting for the present the impressions of Relation, we now view the only other content which he gives the mind, IDEAS, which he defines "copies or reproductions in memory of the foregoing." We are here at the point at which Mr. J. S. Mill was so perplexed. He saw, and acknowledged in his candor, that in memory there is more than a mere copy or a reproduction. There is *the belief that the event remembered has been before us in time past.* We thus get the idea of time always in the concrete; that is, an event in time, and by abstraction we can separate the time from the events in time. We have got more. We intuitively believe that we are the same persons at this present time as we were when days or years ago we witnessed the event. We can not be made to believe otherwise. In this process we are adding knowledge to knowledge, and this a knowledge of ourselves and of other things. These are all revealed to and attested by consciousness, the organ of things internal. The person who would overlook such important facts as these in the animal structure would be terribly lacerated by our acute zoölogist.

3. The next step in the progress of the mind is the discovery of Relations. Hume's account of the relations which the mind can dis-

cover is taken from Locke and improved, and is very large and comprehensive. He makes them to be eight in number: Resemblance, identity, space and time, quantity, quality, contrariety, cause and effect. He exerts all his ingenuity, I believe fruitlessly, to show that these can not extend our knowledge beyond impressions and ideas, which are mere reproduction of impressions. They are relations of impressions and ideas, and not of things. We meet this skepticism on the part of Hume and agnosticism on the part of Huxley by maintaining that what we perceive originally are things, and what we perceive by the faculty that discovers relations are relations of things. When we classify plants by their resemblances, we classify the plants and not impressions. When we decide that a thing which begins to be must have a cause, we have a reality: first, in the thing that begins to be; which implies, secondly, a reality in the cause which we regard as producing it. It is thus that we argue that the present configuration of the earth, being an objective reality, is the result of agencies which acted thousands or millions of years ago. It is thus we argue that the adaptations we see in the eye must have had a cause in an adapting, that is, a designing power. Professor Huxley's account of the relations which the mind can discover is much more meager than that of Hume. Apparently, following Professor Bain, he makes them consist in coexistence, succession, and similarity. He thus gets rid dexterously of the relations of quantity on which mathematics, with all their certainty, so obnoxious to the skeptic, depends; and of identity, which certifies to the soul's continued and permanent existence; and of causation, which leads us from harmonies and adaptations, from order and design in nature, to rise to a producing power in a designing Mind. The three which he acknowledges—similarity, coexistence, and succession—are all regarded as relations among impressions and ideas, and tell us nothing as to realities.

This is the intellectual furniture of the mind, according to Huxley. Observe what it is: Impressions, Ideas, and Relations among these. He calls these the "Contents of the Mind." It is the most miserably defective account of the mental powers I have met with anywhere; more so than that given even by Condillac and the sensational school of France, who gave to the mind a power of transforming its sensations into a considerable number and variety of elevated ideas.

4. Having thus allotted to the mind so small a content, he finds it the more easy to refer the whole to cerebral and nervous action. "The upshot of all this is, that the collection of perceptions which constitutes the mind is really a system of effects, the causes of which are to be sought in antecedent changes of the matter of the brain, just as 'the collection of motions' which we call flying is a system of effects, the causes of which are to be sought in the modes of motion of the muscles of the wings. . . . What we call the operations of the mind are functions of the brain, and the materials of consciousness are products

of cerebral activity." The Professor here defends a doctrine from which I rather think Hume would have turned away. With all his skepticism, Hume was fond of dwelling on mental rather than on material operations. Such sentences show that Huxley may be properly called a materialist. He denies, indeed, that he is a materialist. The fact is, that he is an agnostic, believing in neither mind nor matter as substances. But then he makes all agency material. "The roots of psychology lie in the physiology of the nervous system." He gives a physical basis to all mental action—inconsistently, I think, for I can not find that on his principles he is entitled to seek for any basis. Neither reason nor experience sanctions the doctrine that matter can produce mind; that molecules or masses of matter can think or feel, or discover the distinction between good and evil. At this point Huxley seems to separate from such men as Tyndall and Du Bois-Reymond, who tell us that to bridge the wide gulf that divides mind from matter is altogether beyond human capacity or conception.

5. At this point it will be necessary to refer—I can do so only briefly—to the question so important in philosophy, as to whether the mind discovers some objects and truths at once, and without a process—that is, by intuition. Hamilton, in his famous Note A, appended to his edition of Reid's "Collected Works," has shown that all thinkers, including even skeptics, have been obliged to assume something without proof, and to justify themselves in doing so. In my "Examination of Mr. J. S. Mill's Philosophy" I have shown that, in his "Examination of Hamilton's Philosophy," he has assumed between twenty and thirty such principles. With Locke I hold that the primary mark of these intuitions is self-evidence. We perceive things and truths by simply looking at them. Intuitions are not high *a priori* truths independent of things, but they are involved in the very nature of things, and we perceive this as we look at them. Thus we know, by simply looking at them, that things exist; that if two straight lines placed alongside proceed an inch without coming nearer each other, they will not approach nearer, though prolonged through all space; that two things plus two things make four. Truths thus self-evident to our minds become necessary; we can not be made to judge or decide that they are not true. Necessity is commonly put forward by metaphysicians such as Leibnitz and Kant as the test of such truths. I regard it as the secondary, the primary being self-evidence.

Hume and Huxley have discussed the question of Necessity especially as applied to causation. Hume accounts for it by custom and association of ideas: we are accustomed to see cause and effect together, and when we see the one we are constrained, whether we will or not, to think of and expect the other. But this is not the kind of necessity which metaphysicians appeal to. Necessity as a test of truth is a necessity of cognition, belief, or judgment, arising from our viewing the nature of the object, as, for example, when on contemplating

two straight lines, we perceive, without any mediate proof, that they can not inclose a space. Our commentator on Hume has equally misunderstood the nature of this necessity. He speaks of three kinds of necessity. The first is one merely requiring the consistent use of language: "The necessary truth A = A means that the perception which is called A shall always be called A." This throws no light on our convictions. The second, "The necessary truth that 'two straight lines can not inclose a space,' means that we have no memory, and can form no expectation of their so doing." The instance he gives is a good example of an intuitive truth seen at once, and necessarily believed; but it surely implies vastly more than merely that we have no memory, and can form no expectation of two straight lines inclosing a space; it means that we perceive that, from the very nature of things, two such lines can not inclose a space. He has a third case of necessity, "The denial of the necessary truth that the thought now in my mind exists, involves the denial of consciousness." This is also an example of a self-evident, necessary truth, but it is so because we have an immediate knowledge of ourselves as existing.

6. Hume's doctrine of causation takes a double form; the one objective, the other subjective. These two are intimately connected, and yet they should be carefully separated. Hume held that objective causation is only invariable antecedence and consequence. This is a doctrine contradicted both by metaphysical and physical science. It seems very clear to me that our intuitions, looking on objects, declare that they have power. This is implied in the axiom that we know objects as having properties; and what are properties but powers? Then modern science has established the doctrine of the conservation of energy; namely, that the sum of energy, actual and potential, in the world is always one and the same. Causes are not causes simply because they are antecedents; they are antecedent of the effects because they have power to produce them.

It would be preposterous in so short a paper as this to dive into all the subtilties of the subjective question as to whether our belief in causation is intuitive, or is derived from a gathered experience. The settlement of this question will depend on the way we settle the one started under the last head, as to whether there are not truths which shine in their own light. If there be such truths, then causation is undoubtedly one of them. When we see a thing produced, a new thing, or a change in an old thing, we look for a producing cause having power in its very nature, and ready to produce the same effect in the same circumstances.

7. By his doctrine, defective as I reckon it, Hume undermined the argument for the Divine existence. There is evidence in his life, in his correspondence, and in his philosophic writings, that, like John Stuart Mill, in a later age, he looked with a feeling of favor upon the seeming evidence for the existence of a designing Mind in the uni-

verse. But neither of these men could find a conclusive argument. Huxley follows them here. The three are to be met in the same way. The philosophy of all of them is erroneous. Man has the capacity to discover that, by the very nature of things, everything that begins to be must have a cause. If a world begins to be, if there be a fitting of things to one another in the world, then there must be an adequate cause in a power and purpose on the part of an intelligent Being. Our agnostics can answer this only by making man incapable of knowing anything of the nature of things.

8. According to the philosophy of Hume, there is and can be no evidence of the immortality of the soul. If mind be the product of matter, specially of the collection of nerves, then, on the dissolution of the body generally, and especially of the brain, there is no proof that the soul survives ; indeed, there remain no means, in fact no possibility, of its action. The moral argument so powerfully urged by Kant in favor of a judgment-day and a life to come to satisfy the full demand of the law, is entirely undermined in a philosophy which does not admit of an authoritative and imperative morality, and does not call in a God to make the moral law work out its effects. This skepticism is to be met by showing that mind and matter are made known to us by different organs, the one by the self-consciousness, and the other by the senses ; and that they are known as possessing essentially different properties, the one as thinking and feeling, and the other as extended and resisting our energy. That the body dies, is no proof that the soul must also die. If these truths be established, it is seen that the usual arguments for another life retain their force. Believing in God, and in his law, we are convinced that he will call all men to judgment.

9. But it may be urged that, though the philosophic or scientific arguments in behalf of religion fail us, we may resort to revelation. But both Hume and Huxley deprive us of this refuge. Hume does not, like certain bewildered German speculators, deny the possibility of a miracle. His position is, that there is no evidence to support any given miracle. He defines miracles as "a violation of the laws of nature," and labors to show that the testimony in behalf of a miracle is more likely to be false than that the order of nature should be violated. Huxley objects to his definition of a miracle, as many had done before. But he urges the same objection in a somewhat different form: "The more a statement of fact conflicts with previous experiences, the more complete must be the evidence to justify us in believing it" (p. 133). He decides that there is no such evidence as is fitted to sustain an occurrence so contrary to our experience as a miracle. Huxley advances nothing new on this subject, and the defenders of Christianity maintain that they can meet the objections he adopts. They show, first, that they can produce testimony in favor of certain miracles, such as the resurrection of Jesus from the dead, more full and explicit,

than can be advanced in behalf of the assassination of Julius Cæsar, or the best-authenticated occurrences in ancient times. They show, secondly, that there is an accumulation and a combination of evidence in favor of the life and mission of Jesus Christ: in the prophecies uttered ages before; in the results that followed the propagation of the gospel; and, above all, in the fitness of Christ's work to remedy the acknowledged evils in the world, and in its adaptation to the felt wants, moral and spiritual, of man. It might be shown that the cumulated evidence in behalf of the Christian revelation is not unlike that brought to prove the uniformity of nature.

10. Professor Huxley has nothing original to advance on the subject of moral good. Neither of them holds the selfish theory of morals. Both hold that man has a native instinct which leads him to sympathize with his neighbor, and to be pleased at seeing him happy. So far both are right; but, on the very same ground on which it is shown that there is a disposition in our nature to promote the pleasure of others, it can be shown that there is a principle in our nature which leads us to approve of what is good and condemn what is evil.

We are now in a position to discover and comprehend what agnosticism is, as expounded by its eminent living philosopher. Notwithstanding the meaning of the term, it is claimed by the whole school that there is knowledge gradually accumulating. According to our professor there are sensations, there are pleasures and pains, and among these are relations of coexistence, of succession, and similarity. By observing these we may form science, which is systematized knowledge. He who is master of the sciences is a learned man, and may be very proud or vain of his acquirements. Professor Huxley, as being acquainted with a number of the sciences, is undoubtedly possessed of much knowledge.

What, then, it may be asked, is defective or fault-worthy in the philosophy of agnostics? Its error lies in its avowed fundamental principle that we know only impressions, or, as Kant expresses it, appearances, and do not know things either mental or material. All that we know are impressions—impressions recalled and impressions correlated. The correlations constitute the various sciences.

There are *savants* who have a large acquaintance with these impressions and their correlations. But all the while they know nothing and never can know, or come nearer knowing, the things thus appearing and thus correlated as appearances—if, indeed, there are any things. It is not positively asserted that there are things, but it is certain, according to Kant, followed by Spencer, that there are, unknown and unknowable by man with his present faculties. It is curious to find the metaphysical Hume and the physical Huxley at one on this point.

In one sense Huxley is entitled to deny that he is a materialist. He believes as little in the existence of matter as he does of mind.

But he does claim that the impressions which we call mental are produced by those we call material, namely, cerebral action. So far he is a materialist, and the undoubted tendency of his philosophy is materialistic—he makes matter the basis even of mental action. He is not like Hume a skeptic, for he does not affirm that there are no things: all that he says is, that if they exist we can not know them; or, rather, that things known to us are merely impressions in the shape of sensations—of sensations remembered and correlated. He is not an atheist, not he; he only says that we have no proof of the existence of God. He is simply an honest agnostic—not believing in mind, or in matter, or in God. What is the tendency of such a system?

1. It makes us feel that we are in a world of illusions. I say illusions, and not deceptions; for, as Nature does not profess or promise anything, it can not be charged with intentional deception. But then we may be deceiving ourselves or deceiving others; and agnostics show that we are doing so. I maintain that it strips us of many of our natural beliefs—beliefs which men have entertained in all ages and countries. The great body of mankind believe that they themselves, and the objects they have to deal with, are more than impressions, and that they are realities in a real world; that there is matter that is solid, that there is mind that thinks and feels, that we all possess a soul, and that our neighbors also have souls. I am prepared to show that these convictions are valid; that we have the same evidence of a self thinking, and of body resisting our activity, as we have of the existence of impressions. But suppose these convictions removed, and how do we feel, and what have we left us?

Will we be apt to set a higher value on life when we know it to be a mere bundle of impressions with unsubstantial ideas growing out of them? Will we take a deeper interest in our neighbors when we have come to believe (theoretically, for to believe this practically is impossible) that they too are a mere congeries of appearances? Will we be disposed to do more for the world when we regard it as a set and series of phantasmagoria bound by rigid uniformities of likeness, coexistence, and succession? Will we be more likely to feel that life is worth living for, and that it is our duty to work for its good, when we contemplate it as in fact a mere series of images which do not reflect any reality? Will not one hindrance to self-indulgence be removed when we are made to acknowledge that sensations and pleasures are realities, and that there are no others? Will not one hindrance to self-murder, which we may be tempted to commit when in trouble, be removed when we are sure that we are merely stopping a series of sensations? Will the regret of the learned murderer be deepened when he is told that he has merely laid an arrest on a few pulsations? Will the seducer be more likely to be kept from gratifying his lust when the highest philosophy teaches him that the soul of his victim is a mere collection of nerves? Is the youth who has run in debt less like-

ly to rob his master when he is assured that both he and his master are mere throbs in the vibrations which constitute life? Agnosticism never can become the crêed of the great body of any people; but should it be taught by the science and philosophy of the day, I fear its influence on the youths who might be led, not to amuse themselves with it, but by faith to receive it, would be that they would find some of the hindrances to vice removed, and perhaps some of the incentives to evil encouraged.

2. Thus far as to the influence of the philosophy on common morality. It is allowed that the system undermines all belief in the supernatural. All who know anything of it know this. But some do not realize it. The creed destroys the foundation of all religions, even the rationalistic, not only supernatural but natural theism, not only Christianity but every form of deism. Last century Franklin could say: "Here is my creed: I believe in one God the Creator of the universe; that he governs it by his providence; that he ought to be worshiped; that the most acceptable service we render him is doing good to his other children; that the soul of man is immortal, and will be treated with justice in another world respecting its conduct in this. These I take to be the fundamental points in all sound doctrine" (from letter by Hon. J. Bigelow in "New York Observer," July 3, 1879). But the superstition which clung to Franklin in the eighteenth century is all dissipated by the philosophy of this century.

Shrewd men have long seen and often said that, if Christianity be set aside, deism will soon follow. We see this already realized. Agnostics feel an avowed pleasure in pointing out the positive contradictions involved in every form of natural religion. All who adopt the system should know that they must be prepared to part with all the consolation that can be derived from religion, natural or revealed, and from all the restraints which it lays on evil conduct. Some may be rejoicing in agnosticism because it relieves them from all ghostly terrors; but it does not therefore follow that their happiness will be increased. I am aware that speculative beliefs do not always lead to corresponding practice; but their tendency is to do so, and when they do not it is because they are counteracted by opposing principles good or evil. I am sure that agnosticism, when it has time to work, will be followed by important consequences. I am not to be charged with the fallacy of arguing that, because a system is charged with bad results, it must therefore be false. I am showing that the system is false, and thus leads to prejudicial consequences—false to our nature, false to the ends of our being.

THE AGE OF CAVE-DWELLERS IN AMERICA.

By E. T. ELLIOTT.

THE various writers and thinkers on the subject of pre-historic man generally concede that the races of to-day have radiated over the globe from some point in Asia. Indeed, the traditions of different nations lead to the conclusion that this point of dispersion was located in the high central regions of that country. There, apparently, the dog, horse, and ox were first domesticated, and can at the present time be found in their natural, wild state. Hudson Tuttle says, in his "Arcana of Nature," that "man originated near the equator, where the climate was better adapted to his defenseless condition and food abundant."

This conclusion seems to be based upon the impression that the different zones of the earth occupy the same relative positions now that they have always done, and can hardly hold good in view of recent developments. Colorado, an almost unexplored country, comparatively speaking, to the scientific world will be apt to change the logical reasonings that have so far been advanced upon this interesting subject.

Señor Altamirano, of Mexico, the best Aztec scholar living, claims the proof is conclusive that the Aztecs did not come to Mexico from Asia, as has been long universally believed, but that they were a race originated in the unsubmerged parts of America, as old as the Asiatics themselves, and that *that* country may even have been peopled from this. From the ruins recently found, the most northern of any yet discovered, the indications of improved architecture, the work of different ages, can be traced in a continual chain to Mexico, where they culminate in massive and imposing structures, thus giving some proof by circumstantial evidence to Altamirano's reasoning. But now, as to the antiquity of American man as shown by the yet recent discoveries in Colorado.

First it will be necessary to glance at the glacial period for an instant, or rather at the geological spring following it, when the warm rays of the sun turned the ice-covered crust of earth into a vast sheet of water, with only the extremely high ground left exposed above its surface.

From the evidences of the rocks and the deposits of the mountain valleys it is fair to deduce the conclusion that, as in time the waters gradually receded, the first part of America to assume any dimensions was the backbone of the continent, or that elevated portion known as the Rocky Mountains, which had probably never at this period been entirely covered with water, thus affording a long, continuous stretch of dry ground on which man and beast could live and wander as they listed.

At this period, it has been stated by many and believed by most, that the present line of the equator was where man originated and flourished, because of the warmth of the climate and abundance of easily procurable food. Yet the evidences in Colorado are opposed to this belief, for *here* were the tropics also.

The existing specimens of perfectly-preserved petrified palm-trees show this, so also do the petrified remains of gigantic turtles peculiar to tropical waters alone. The Asia theorists also offer the nativity of the horse as a strong argument in their behalf, claiming that man and horse developed at about the same time. If this claim has any weight, it more than settles the point in favor of America, for the fossil remains of horses with three toes to each foot have been found in Colorado, and the examination of any hoof of a horse in embryo will show this to have been one of the earliest stages in the existence of that animal. This evidence goes beyond the researches of the supporters of the Asia theory, for their conclusions are based upon the fact of the existence of the wild horse of the present time.

These evidences of tropical life in Colorado, it must be remembered, are found at an altitude of ten thousand feet, or near the present snow line. As the waters gradually receded, they left the valleys and parks throughout the mountains immense lakes, until a trickling and overflowing outlet wore its way into a deep cañon through solid granite, and liberated the pent-up waters of each.

The San Luis Valley, in which Del Norte is situated, is in the southwestern part of Colorado, and is from sixty to seventy miles broad by about three hundred miles long, and the outlet for drainage is now the beautiful snow-born Rio Grande.

Hearing one day in December, 1877, that a gentleman acquaintance, in wandering over the foot-hills, about three and a half miles from Del Norte, had found a small arrow-head of chalcedony, it aroused my curiosity, and I at once called upon him that I might see it. He showed me a beautiful specimen of elegant workmanship, made with great care and accuracy as to dimensions, but evidently intended for an ornament, being too small and delicate for any other actual use.

The present Indians never work in chalcedony, and I felt sure some discoveries might be made by visiting the spot; so, calling together a couple of friends, we mounted our horses and had a delightful canter over the floor-like valley until we reached the base of the hill on top of which the specimen had been found. We dismounted, tied our horses, and began climbing up and up for several hundred feet above the valley, pausing now and then to breathe and enjoy the magnificent view extended at our feet—the valley stretching away like an ocean of molten gold, with its autumn-tinted grasses, a hundred miles to the north and seventy miles to the east, where it came to an abrupt ending against the solid bases of the majestic peaks comprising the Sangre-del-Christo range of mountains. No foot-hills inter-

vened to obstruct the view; the clear-cut and sharply defined peaks stand in an unbroken file, an army of Nature's monarchs, clad in Nature's livery, a uniform of perpetual green, and crowned with helmets of eternal snow.

We finally reached the summit—our objective point—and began winding our way around huge obelisks of sandstone, and through a perfect net-work of passages and crypt-like fissures. We felt as though we had entered the Cretan labyrinth, but, not so fortunate as Theseus, had no thread to guide us, until we came upon the first ancient habitation.

Climbing through a narrow crevice with some exertion, we observed a cave-like opening in the rock fronting us, and of course were but an instant in gaining an entrance, where we were delighted to find, upon examination, the evident handiwork of man.

Here was an apartment about six by eight feet in size, where nature had formed two sides and the sloping roof. One side had been left open, and the other, from the yet remaining fragments, showed plain evidences of having been roughly walled up with loose stones. A fissure in one corner of the room, leading out through the roof, showed traces of discoloration by fire, and digging down with some sticks through the rubbish, we found that corner had been used as a fireplace, and at a depth of eighteen inches we still found the wall with strong evidences of the action of heat on the stones, finally unearthing some charcoal, and from a repository in the wall about a half peck of chips of chalcedony: judging from this latter *find* that we were in the workshop of the former inhabitants of the place.

We were not prepared for excavating through the dust of ages which Time had caused to settle on the floor, so started out eager to find other places of habitation. Our search was rewarded by finding during the afternoon some twelve or fifteen more houses or caves, many of them, however, especially those along the face of the cliffs, having nearly disappeared from the effects of the disintegration of the rocks.

We found no more dwellings as large as the workshop, the majority of them being very small, the rough traces of walls nearly always visible, but the caves so circumscribed in extent it seemed impossible that human beings could have lived in them. Yet each one had its fireplace plainly to be seen, and each one had certainly been at some time a dwelling or shelter from the elements.

Continuing our search, we also found two furnaces—primitive, 'tis true, but none the less furnaces—showing the effects of great heat, and a deposit of dirt-covered ashes several feet in depth. These furnaces were hollowed out of immense bolwders by man or nature—we could not decide which, owing to the action of the fire—and the interior of each almost exactly resembled the interior of a Dutch oven, having in like manner a small orifice for draught.

They appeared to be mostly the work of nature adopted with but little change, if any, by man for his own uses. However, on this point the different members of the party failed to agree.

What this race cooked, baked, or burned in them yet remains to be seen. From the quantity of the deposit, and as no human remains have been found, nor any semblance of graves, it may be that their method of disposing of the dead was by cremation.

Now, who and what were these people? The modern Indians know nothing of them, never inhabit caves, and say that none of their traditions show that their ancestors ever lived in them.

They could not have been a race of giants, for the caves inhabited by them were too small for their accommodation. Yet here was a colony living at an altitude of eight thousand feet above the level of the present sea, the nearest water at this time being the river two and a half miles away, and to reach it an abrupt descent must be made of several hundred feet. Appearances and surroundings indicate that these caves were inhabited during the period when the San Luis Valley was an immense lake or sea; and when *that* valley was a *lake* where was the rest of America? The valley is seven thousand feet above the ocean, and a natural inference would prompt one to conclude that most of the continent was under water.

I will here state that though interested in the subject, I am not enough versed in it to venture my opinions before those who have made it a life-long study, but would ask, If the cave-dwellers were among the earliest developments of man, and these Colorado men were cave-dwellers at the period of general moisture, with a tropical climate preceding them, is it reasonable to suppose that they could reach this point from Asia?

It is easy to follow these people from their traces as they improved in knowledge with time. They passed southward, apparently following the warm climate, stopping for ages at a time in some *now* sterile valley, which when occupied by them must have been rich and fertile; their gradually improving architecture extending down the La Plata, Mancos, San Juan, and Colorado Rivers, through Arizona, and, as I before said, culminating in the comparatively modern buildings of the highly intelligent Aztecs.

CHLORAL AND OTHER NARCOTICS.

By Dr. BENJAMIN W. RICHARDSON, F.R.S.

I.

IT fell to my lot to be the first in this country to investigate the action of hydrate of chloral after the remarkable discovery of its properties as a narcotic by the distinguished and original Liebreich. At the meeting of the British Association, held at Exeter in the year

1868, the late Mr. Daniel Hanbury, F. R. S., brought with him to the meeting, from Germany, a specimen of the hydrate and a brief verbal account of the phenomena which it had been found to produce on living bodies. The facts related by Mr. Hanbury proved of so much interest to the members of the Biological Section, that they elected me, who had just been submitting a report on an allied subject, to make a further and special report during the meeting on this particular subject. I accepted the duty at once, and conducted a series of experimental researches, the results of which were duly laid before the section on the last day of the meeting. The results were among the most singular I had ever witnessed, and the report upon them raised an intense curiosity among the medical men and the men of science in this country. Liebreich's discovery became the physiological event of the year, and for some months I was engaged, at every leisure moment, in demonstrating the various and unique facts which that discovery had brought forth.

In this chloral hydrate we were found to possess an agent very soluble and manageable, which, introduced into the body of a man or other animal, quickly caused the deepest possible sleep, a sleep prolonged for many hours, and which could be brought so near to the sleep of death that an animal in it might pass for dead and still recover. In this substance we also found we had an agent which was actually decomposed within the blood, and which in its decomposition yielded the product chloroform which caused the sleep ; a product which distilled over, as it were, from the blood into the nervous structure, and gave rise to the deep narcotism.

The discovery of Liebreich opened a new world of research, the lessons derived from which I shall never forget. And yet, now that ten years have passed away, and I have lived to see the influence on mankind of what is in one sense a beneficent, and in another sense a maleficent substance, I almost feel a regret that I took any part whatever in the introduction of the agent into the practice of healing and the art of medicine.

About three months after my report was read at the meeting of the British Association for the Advancement of Science the first painful experience resulting from chloral hydrate came under my knowledge. A medical man of middle age and comfortable circumstances took, either by accident or intention, what was computed to be a dose of 190 grains of chloral hydrate. He had bought, a few days before this event, 240 grains of the substance. He took a first dose of ten grains in order to procure sleep. On a following night he took twenty grains, and on the evening of the succeeding day twenty grains more. These administrations were known. He had reduced his store by these takings to 190 grains, and, while in a state of semi-consciousness from the last quantity, he got up from the bed on which he was reclining, and emptied all the remaining contents of the bottle into a small tum-

bler of water, and swallowed the large dose so prepared. He was found insensible, with the bottle and glass by his bedside. He did not fully regain consciousness for sixty hours, but finally made a good recovery.

The occurrence of this experience led me into a new line of research, namely, to find out what was the best mode of maintaining life while the body is under the influence of a deep sleep from the hydrate. This new research disclosed that the great object of treatment should be to sustain the animal temperature. I found that, like alcohol, the tendency of chloral hydrate is to reduce the vital fire, and that of two animals under chloral, one in a warm, the other in a cold atmosphere, the recovery of the one in the warm and the death of the one in the cold atmosphere could be reduced to a matter of positive system or rule. I had soon to publish that lesson, and to indicate that there were dangers ahead in respect to the use of chloral hydrate, which dangers would have to be scientifically combated.

Within a year after the introduction of chloral hydrate into medical use another new truth dawned on me. One morning the friends of a gentleman called on me, bringing a bottle of chloral hydrate and a copy of a medical paper containing a lecture of mine relating to the action of the drug. They had noticed for some time past that the gentleman, about whom they were anxious, had been very peculiar in manner, exhibiting signs resembling those of intoxication from alcohol, but with more than alcoholic somnolency. He was an alcoholic, and sometimes he was apt to have spells of inebriation ; but the phenomena more recently observed were somewhat different. Watching him closely as their alarms increased, they detected that he was in the habit of dosing himself with some substance which he kept in a series of bottles, of which he had seventeen or eighteen in stock, and one of which they brought to me. The bottle they brought contained chloral hydrate, and it turned out that all the bottles contained, or had contained, the same. By and by this gentleman came to me himself, and confessed that he was in the habit of taking the chloral three or four times in the twenty-four hours. He took it at first, after reading my lecture on its medicinal uses, in order to procure sleep. It answered his purpose so well that he became induced to repeat the process, and in a little time got what he called his new craving. He presented a series of special symptoms from the chloral which had some of the characters of jaundice and some of the characters of scurvy. These symptoms were additional to the signs of brain and nervous disturbance caused by the chloroform derived from the chloral, and they were easily accounted for. The chloral, in undergoing decomposition within the body, divides into two products, the one chloroform, the other an alkaline formate, a soluble salt, which makes the blood unduly fluid, and acts much in the same manner—as I found again by direct experiment with it—that common salt does, or the mixture of pickling

salts used for the preservation of dead animal tissues that are preserved by the process of salting.

Here, then, was another history of danger from the use of chloral hydrate, a new condition of disease to which I drew attention very speedily, and to which I gave the name of *chloralism*. It is a matter of deep regret to have to report that since the name was given to the disease chloralism has become rather wide-spread. It has not yet spread far among the female part of the community. It has not yet reached the poorer classes of either sex. Among the men of the middle class; among the most active of these in all its divisions—commercial, literary, legal, medical, philosophical, artistic, clerical—chloralism varying in intensity of evil has appeared. In every one of the classes I have named, and in some others, I have seen the sufferers from it, and have heard their testimony in relation to its effects on their organizations—effects exceedingly uniform, and, as a rule, exceedingly baneful.

The history of chloralism is of interest to the scholar of history as showing how easily a simple scientific discovery may be misapplied when its misapplication ministers to some luxurious desire or morbid inclination of mankind. I give the account at first hand, drawing upon no other experience than my own, an experience which dates from the first commencement of the disease, and which, during all the period, has been probably, in this country, as comprehensive as any in respect both to instances of acute and of slow mischief from this one cause. I could fill easily all the space allotted to me in the present essay by mere narration of observed facts on this topic, were that my object. My object does not lie in that direction, useful and practical though it might be. Let the reader simply remember that from a certain scientific basis of research something specifically social, and either moral or immoral in its tendencies, has occurred in a brief space of time, and that a singular mental phenomenon has been developed among the most cultivated representatives of a highly cultivated people, and the impression I wish now to indicate by the brief narrative recorded above is supplied.

This is not the first time in the history of mankind that the same kind of history has been written. There is a previous history, from which dates a great deal that is curious in romance and poetry, and which even to Shakespeare afforded a world of wonder and of story.

The ancient physicians, dating from Dioscorides himself, tell of the use of a wine made into a narcotic by mandragora. From the leaves and from the root of the *Atropa mandragora* the ancient physicians prepared a vinous solution which in many respects had the same properties as the chloral hydrate of to-day. This wine, called "morion," was given to those who were about to be subjected to painful surgical operations or to the cautery, so that, ere the sensitive structure was

touched, the sick man was in a deep sleep during which the operation was performed without the consciousness of feeling, not to say of pain. The sleep would last for some hours. From this purely medical or surgical use of morion, the application of it extended. Those who were condemned to die by cruel and prolonged torture were permitted to taste its beneficence and to pass from their consummate agony through Lethe's walk to death. A little later and the wine of mandragora was sought after for other and less commendable purposes. There were those who drank of it for taste or pleasure ; and who were spoken of as "mandragorites," as we might speak of alcoholics or chloralists. They passed into the land of sleep and dream, and waking up in scare and alarm were the screaming mandrakes of an ancient civilization.

I have myself made the "morion" of that civilization, have dispensed the prescription of Dioscorides and Pliny. The same chemist, Mr. Hanbury, who first put chloral into my hands for experiment, also procured for me the root of the true mandragora. From that root I made the morion, tested it on myself, tried its effects, and re-proved, after a lapse of perhaps four or five centuries, that it had all the properties originally ascribed to it. That it should have come into use as a narcotic by those who first tasted it for its narcotic action, and that they should have passed into mandragorites, is not more surprising than that other and later members of the human family should have become chloralists. The effects produced by morion subjectively and objectively are so much like those from chloral that they may be counted practically as the same. I have put these two examples of the action of two similar toxic agents in parallel positions, because they are remarkable as showing how, at most distant and distinct eras of civilization, a general practice in the use of these agents sprang out of a special practice relating to their use, a maleficent out of a beneficent purpose. If I wished to extend the comparison, I might place opium, ether, chloroform, and chlorodyne under the same category.

Mandragora, opium, chloral, ether, chloroform, chlorodyne, are medical agents used in the first instance mechanically, and used in a second instance socially, and by habit in certain instances, for the purpose of making the mind oblivious, or, in other and more frequently used words, for securing repose or rest. These agents do not stand alone in respect to the list of toxicants which are assumed to be useful to mankind. To them must be added many others which have not necessarily had an origin from medical science or art, but have sprung into general use from their first application. Under this head may be included the commoner members of the chemical families known as the alcohols : hasheesh from the *Canabis indica* (Indian hemp), yerba de nuaca, or red-thorn apple, almanitine, coca, absinthe, arsenic, tobacco.

It will be seen that the toxical agents are a numerous class, and, if I had chosen to refine, I might have added some further. In one

notable instance, and in one or two less notable, nitrous-oxide gas, the gas now so commonly used by dentists as an anæsthetic, has been resorted to as an habitual stimulant and narcotic; but the rarity of its use prevents the necessity of doing more than referring to it in this place, and once perhaps again in the sequel. Of the other agents it may be said, *in limine*, respecting the extent of their use, that the alcohols and tobacco stand first on the list in our civilized life. Next after these come opium, absinthe, chloral hydrate, chlorodyne, ether, and chloroform. The other substances are local in the range of their employment. Hasheesh is an Eastern luxury; amanitine a Kamtchatkan luxury; arsenic a Styrian luxury; red-thorn apple a luxury of the Indians of the Andes, under the sweet influence of which they enter into communion, as they believe, with the spirits of their departed dead—the best excuse I have ever heard given for the use of any of these indulgences whatsoever.

As we cast our minds back upon this long list of toxical instruments for the delight of man, we are struck with the widely apparent difference that seems to exist between them. The difference, however, is not so great as it may seem, for between the physiological action of one and the other there is an analogy of action in certain particulars which is singularly striking. As a rule, the key-note of the action of these agents, if I may use such a simile, is through one particular element where many elements enter into their composition. Where nitrogen is present as an element, a definite line of action of the agent is marked out; when a hydrocarbon radical is dominant—that is to say, when such a radical forms the chief part of the compound—the influence of that is most definite; while the influence of one disturbing principle on another may be most clearly traced in other cases as a neutralizing influence, one influence reacting upon the other.

We have at hand many instances of this kind for illustration. Alcohol and tobacco are the most ready examples. In the alcohols, whichever one of the family of alcohols we may take, from the least dangerous wood-spirit, through the more dangerous grain-spirit, up to the much more dangerous potato-spirit, there is one agency at work, a hydrocarbon radical, methyl, ethyl, amyl, according to the alcohol used, which, with different degrees of intensity, plays the same part, producing similar series of phenomena. In tobacco we have a less decisively known combination at work, but we have in that combination the element nitrogen, the introduction of which causes a new development of nervous phenomena, the analogous action of which can be traced through some other complex organic compounds containing the same element—nitrogen. In chloroform, again, we have a hydrocarbon radical playing nearly the same part as the radical methyl of methylic alcohol, but with chlorine interposing to modify the simple narcotic action of the radical, and greatly to increase the danger of

the compound in its effect on the living body. Physiological research has not yet reached, by vital analysis of action, a perfection of knowledge on the subject now in hand. Such analysis is yet in its early days. At the same time a general line of research has been made out, and some results have been obtained which are of direct practical value. Other facts have also been elicited which at first sight are surprising, but which lose their singularity when they are correlated with pure chemical physical demonstrations. I found, for example, in one of my researches, that two chemical substances which are isomeric in constitution—that is to say, are composed of the same elementary forms in the same proportions, but under different arrangement—produce entirely different phenomena on the animal body. These isomeric substances are the formiate of ethyl and the acetate of methyl.

The agents used by man for his dreamy delights have thus a varied influence on his nature. They are often rudely classed together as luxuries; but the luxuriousness which they foster may be fathoms wide until they so far interfere with vital function as to reduce its activity in a notable degree. Then there is something in common between them, just as there is something in common when, being carried a little further, they stop life altogether.

For this is interesting respecting them, in the most potent sense. They all kill when we let them have full play. This is obviously the reason why they are called toxicants and intoxicants. They bear resemblance in action to the poison which once in the history of a past civilization sped on the tip of an arrow from a discharged bow.

The toxicants have variation of action in their early stages. Alcohols excite the mind and quicken the pulses before they depress. Opium excites before it depresses. Tobacco does not in the strict sense excite, but depresses and soothes from the first, so that there are stages, which some persons always feel, when alcohol is antidotal to tobacco. Among those persons who are total abstainers from alcohol few are found who can bear tobacco in the most moderate use of it. Under tobacco the heart seems rapidly to run down in power, and alcohol is called for to whip it up again, also as it seems. The fact is, that the heart is not the organ primarily concerned at all, but the minute vessels at the termination of the arterial circuit. These minute vessels are under a nervous influence by which the passage of blood through them is regulated, and which influence is readily modified by very refined causes acting through the organic or emotional nervous centers. The effect of tobacco on these minute vessels, through the nervous system, is to cause contraction of them as a primary fact, so that the face of the person affected becomes pale and the surface of the body cold, while the heart labors to force on the supply of blood until its own vascular system comes under the influence: then the stomach involuntarily contracts, and, after a time, the voluntary

muscles, deprived of blood, convulse tremulously, or pass into active convulsions, as in tetanus. Alcohol, on the other hand, through its influence on nervous functions, relaxes the vessels of the minute circulation, sets free the heart, reduces the muscular power, and in every particular counteracts the tobacco. When a person receives a stun, or is shocked by some intelligence, or sight, or sound, that thereby stuns him, so that, like Hamlet, he is bechilled

> "Almost to jelly by the act of fear,
> Stands dumb and speaks not,"

he is for the moment in the same state as the man who first tries to smoke tobacco, and who, with pallid face, cold surface, and reeling brain, is to his sense and feeling stricken with all but mortal suffering and prostration. In each of these cases alcohol, for a moment, acts as an antidote not necessarily as the best antidote, but as a fair one. When, therefore, we see a man smoking and drinking, quaffing off the cup of wine or spirit to quiet the qualm which would otherwise be inflicted by the fumes of the cigar or the pipe, we really observe the facts of a most excellently though innocently devised physiological experiment on a living animal. The man, unconsciously to his knowledge, if not to his sensation—unless he be a physiologist—is inducing a balance in the tension of his arterial circuit.

In process of time the nervous system, becoming accustomed to these influences, one or both, in a certain degree tolerates them, for a period. The tolerance while it lasts is an advantage to the habit, and, if the habit were a necessity, it would be a blessing. But the advantage is not permanent. In the end the nutrition of the organic parts which are under the influence of the same nervous regulation is sure to suffer, and in many organizations to suffer rapidly and fatally.

It is probable, if not as yet provable, that all the agents named above produce their specific effect by the influence they exert over the automatic, self-regulating nervous function. In my researches on the action of some substances on the minute circulation, I have been able to differentiate their action by this general rule. The alcohols, the lighter alcohols, including common alcohol, relax the vessels; nicotine constringes; chloroform, by virtue of the chlorine in its composition, constringes; opium relaxes, then constringes; ether relaxes; absinthe, after a time, constringes; chloral hydrate first constringes, and afterward relaxes. From these differences of action the differences of phenomena in the persons affected are explainable. In like manner the ultimate deleterious effects of these agents on the nutrition of the body are explainable. It is a necessary result, for example, that under the long-continued use of alcohol the constantly relaxed and congested vessels should assume a new character and local function; that the parts depending on them for their supplies of blood should be changed from the natural structure to unnatural but definable, and now well-

understood conditions of disease. It is an equally necessary result that under the continued influence of opium the constantly constringed vessels should assume a new local function; that nutrition should be arrested in the parts which those vessels supply with blood; and that the shrunken, impoverished body of the confirmed opium-eater should be an outward and visible sign of the internal changes which are being so assiduously and determinately carried into effect by the narcotic.

When these facts respecting the direct physical action of various toxical agents on the body, through the line of the involuntary nervous system, are understood, they connect, through the same direction, the effects of more refined and much less definable influences. They show how psychological phases are ever at hand to modify nutritive changes: how grief, which shocks and dissevers the organic nervous supply, affects the animal life so deleteriously, exciting and reducing, and sometimes in part disabling altogether parts of the organic nervous track. They indicate how an equable nervous current is conducive to permanent nutritive activity and health, and show physiologically that to laugh and grow fat is after all a mechanical proposition. I must not, however, be tempted away into an inviting field of observation, in which the physical and the metaphysical so neatly blend.

It is worthy of remark that the action of the different toxicants to which I am directing attention, and which are in most common use among members of the human family, have in some cases a similar action, and in other cases a dissimilar action on the members of the lower creation. The alcohols appear to possess a toxical influence throughout all the domain of living animal beings. I can find no animals that escape the immediate action of the alcohols, or the remote effects which occur when the changes excited by the alcohols are often repeated. All our domestic animals come quickly under the ban. Birds and fishes do the same. Chloroform, chloral hydrate, and absinthe seem to exert a similar wide range of action. Tobacco is not so extended in its range. There are animals that can take with perfect impunity a dose of tobacco which would poison three or four men. The goat is an animal which can resist the noxious, but to it innoxious, weed.

Opium can be resisted by certain animals with equal readiness. A pigeon will practically live on opium. A pigeon will swallow with impunity as much solid opium as would throw twelve adult men into the deepest narcotism. Indeed, it is not correct to say that to pigeons opium is in any sense a poison.

The reasons for these exceptions are not clearly made out. The probability is, that the animals which take the intoxicants with so much impunity produce some form of decomposition of the agent in their own bodies, by which the active alkaloidal substance is rendered neutral in effect, or, at all events, is much neutralized.

There is a fact of singular interest in relation to the intoxicants I have now described or named, and which before I proceed further should be carefully noticed. The fact is this: That when the agents produce a definite effect upon a living body, whether it be a human body or the body of an animal that possesses desires and likings, there is caused in that body, after a number of times of practice, a craving or desire for the agent that produced the effect. In man this is so marked that the most repugnant and painful of lessons connected with the first subjection to the agent is soon forgotten in the acquired after-sense of craving or desire. It really matters little which of the intoxicants it is that is learned to be craved for; the craving for it will continue when it has struck an abiding impression. We know this fact well from the wide experience that has been gained of it in the cases of alcohol, tobacco, opium, chloral, hasheesh, absinthe, and arsenic. More incongruous things could scarcely be; incongruous to the senses, to the sensibilities, to the methods of taking, to the result of them; yet the craving for any one of them as it is may be established. The devotee to one will laugh at the devotee to another; each one will consider the other almost insane, and yet each will follow his own course.

Still more curious is it that the substances craved for, which lie quite outside the natural wants of healthy life, may be extended to any number. There is in truth hardly a substance to which the craving may not cling. The distinguished Dr. Huxham had under his observation a man who, after a little practice in the habit of taking it, had a craving for the salt now called bicarbonate of ammonia. The man chewed this salt and swallowed it in the same way as he might have swallowed peppermint lozenges. The effect of the salt was to produce extreme fluidity of the blood of the man, so that he became scorbutic, and to cause loosening of his teeth. It also reduced his strength, and even placed his life in jeopardy; and yet his craving for the ammonia remained unappeased until his danger was so great that the noxious thing had to be withheld altogether. The great Sir Humphry Davy gives another, and it may be still more remarkable, experience in relation to himself. When he was making his wonderful researches with nitrous-oxide gas, he commenced, at first for the mere sake of experiment, to inhale the gas in free quantities. By this process of inhalation he obtained the most delicious of visions. Space seemed to him illimitable, and time extended infinitely, so that coming out of one of these trances he exclaimed: "Nothing exists but thoughts; the universe is composed of impressions, ideas, pleasures, and pains!" In course of time Davy, by the frequent repetition of the process of inhalation, became so infatuated that he could not look at a gasholder, could not look at a person breathing—I am using his own description—without experiencing the urgent sense of desire to once more imbibe his favorite gaseous nectar, and revel in his induced and artificial dreams. How

closely this confession runs, even from the pen of a philosopher, to similar confessions made by many who are not philosophers, respecting another purely chemical intoxicant which is more generally known than Sir Humphry's gas, I need not stay to explain.

An experience, closely allied to the above, occurred to a scientific friend of mine in relation to another intoxicant—namely, chloroform. This gentleman, commencing like Sir Humphry with the inhalation of chloroform for purposes of experiment, at last began daily to inhale a certain measured quantity. In a few days he increased the quantity, and at last discovered, from the intervals of time which elapsed after he commenced each inhalation, that he must have gone off into deep sleep and so have forgotten to note the passage of time. At first the sense of desire to repeat the inhalation alarmed him greatly, but soon the desire overcame all sense of fear, and at last he became a complete devotee to the practice. A break-down in his health led him to communicate his position to his friends, and by the earnest advice and warning of one of them he did at last resolve to abstain altogether. It was a very difficult fight, the odor of the vapor whenever he was near to it recalling most keenly the old desire, and even four years elapsed before he felt himself fully emancipated from the dangerous habit.

The craving attaches itself to other substances than I have hitherto named. I have known it connected with that most nauseous of all medicines, asafœtida ; I have known it strongly attach itself to another medicine, valerian ; and once I knew it attach itself to turpentine. My learned and very good friend the late Dr. Willis, of Barnes, had a patient who acquired the craving for common wood or methylated spirit ; and there are many who have acquired a liking for spirit that is flavored or more than flavored with fusel-oil.

The readiness with which mankind will attach themselves to varied cravings is shown again and on a comparatively large scale in the north of Ireland. In a district there, of which Draper's Town is the center, the eminent Father Mathew labored in his lifetime with such magical effect that he practically converted the whole district to sobriety. A little after his time, and when the influence of his work was fading away, a person came into the district and introduced a new beverage or drink which was not whisky, which was not strong drink, and which, it was said, would do no harm. The bait took, and for over thirty years there has existed in the place I have named a generation or two of ether-drinkers. I have visited this place recently and found the habit still in progress. The ether-drinker tosses off his two or three ounces of common ether, as another man tosses off gin or whisky. He passes rapidly into a state of quick excitement and intoxication, is often senseless for a brief period, and then rapidly regains the sober state. He suffers less from this process in the way of organic disease than he would from a similar number of intoxications from alcohol; but he gains, as he would from alcohol, the same intense crav-

ing, and the craving presents a similar automatic and periodical rule as has been observed in relation to the habitual employment of other active and enticing poisonous compounds.

The nature of these cravings is not more singular than their intensity, when once they have been acquired. The most practiced craver can rarely succeed in explaining upon what the craving really depends. It is an indefinable desire. It is neither thirst, nor hunger, nor pleasure, nor reasonable want. It is rather like a wish to be relieved for the moment of some indescribable sense of pain or discomfort. It is often periodical in its occurrence, and it can, I believe, always be made perfectly periodical, a fact which connects it very closely with the work of the organic nervous system. In a word, in the confirmed craver the work of the organic nervous system, which is singularly periodical and rhythmical in the natural state, is, by these agents, turned into a new direction, and is made to take on a new action which in steady form repeats itself. I have in my house an eight-day clock which, though a century old, does good and faithful work, except at two times in the twenty-four hours, when it goes periodically astray. From some little twist or wear in the machinery, it stops for a moment in the act of striking at one particular stroke of the bell, and on listening to it it seems as if the striking had concluded. Then it strikes feebly and goes on again all right. The working of the involuntary nervous system in health is as automatic and regular as the working of the timepiece; damaged, it is as systematically deranged at particular periods.

The injury from intoxicants, after the first automatic derangement has been established by them, is not to be measured altogether by the first and usual derangement. Unfortunately, the action of the intoxicant extends beyond the mere effect of the craving that springs from it, and involves in its evils structural parts of the animal body. The nutrition of the degraded structures, the sense of muscular and mental fatigue is soon rendered easy of development; and, *pari passu*, the mind, seeking for aid in the influences it likes, finds a supposed aid in the intoxicant. It takes the destructive agent more frequently, thereby establishing a more frequent periodicity of desire, and a more earnest craving. By these combined influences, as is so commonly observed in the intemperate from alcohol, the craving increases as the animal powers decline, and the tendency to death is vastly quickened in its course. To ordinary comprehension, in these instances, the craving and the sinking are the same acts. They become so at last in effect, but their beginnings are quite distinct, and they are, in the strictest expression of fact, distinct phenomena even to the end.

The craving for these intoxicants, so strong in the habituated among men, is not confined to human kind. The beast that can be brought to taste these agents, and that can be affected by them, can be equally well taught to crave for them, and to look out for them also

with automatic and periodical precision. I know of no domestic animal that can not be trained to look out for these agents when the training is conducted with skill and with determination. Like young children, and those persons of later life who have never tasted the agents in any form, nor experienced the sensations which come from them, the lower animals reject them at first, strive against them, and evidently are much disquieted and perplexed by the results which follow their use. But to err is inhuman as well as human, and so the beasts that perish, even they err and learn to like it. In the beast as in the man, the train of events follows the same course. The craving becomes connected almost immediately with deterioration, and at last the two conditions of desire and decay are spun into the same woof, and appear as the same substance.—*Contemporary Review.*

THE BRIGHTNESS AND DISTRIBUTION OF THE FIXED STARS.

By HENRY FARQUHAR.

THOSE who view and admire the starry canopy above us—so fittingly associated, in the oft-quoted language of a great philosopher, with the moral nature of man—can hardly fail to remark how largely their pleasure in the grand prospect is due to the endless variety in its brilliancy. Just as the magnificence of mundane potentates is fully brought out only by the presence of a long train of inferiors more modestly arrayed, so Sirius and Capella would be less splendid had they not a multitude of lesser luminaries to heighten their glory by contrast. And how many hundreds of twinkling points, almost lost in the wide abyss, are there for every star of highest rank! In the proportion of common soldiers to captains, and of captains to corps commanders, this silent host of heaven is not unlike the less stately armies that tread earth instead of ether. And if astronomers have hitherto interested themselves less in questions of precedence and seniority than in the particular spot on the field occupied by each individual in the great array when drawn up for review; if, dropping the figure, differences of luster and the number of stars of the various grades have occupied less of their attention than the comparatively dry details of right-ascension and declination, with all the refinements of precession, nutation, aberration, proper motion, parallax, refraction, etc., affecting these—they are now making some amends for their neglect. The methodical study of stellar brightness belongs almost entirely, however, to the present century, Sir W. Herschel's first paper calling attention to the importance of the subject having appeared in

the publication quaintly termed "Philosophical Transactions" of the London Royal Society in 1796.

Sir W. Herschel here mentions the number of variable stars, constantly increasing under new discoveries, very naturally predicts that closer observation will be likely to show variability in objects previously unsuspected, and recommends that careful comparisons be made from time to time between neighboring stars all over the heavens, so that any change occurring may be at once detected. The original comparisons accompanying this paper have been of but little use, however; they are interesting chiefly as having been the first attempt to introduce scientific methods into this unexplored territory of the astronomical realm. They were made without the aid of any instrument, and consisted of such indefinite statements as—"Star No. 7 about equal to No. 4, and just perceptibly fainter, or decidedly brighter, than No. 12." The difference of brightness which Herschel considered as "just perceptible" seems to have been from one fifth to one fourth of a magnitude.

That his least appreciable difference should have some constant relation to the traditional "magnitude" was to have been expected, bearing in mind what this oldest and most universal scale of reference was intended to express. The fixed stars were assigned to classes of brightness, we learn, before the Christian era; and the very term "magnitudes," used from the first to designate these classes, shows the state of knowledge under which the study had its origin, for, as we now know, the apparently greater size of the brighter stars is due only to imperfections of the eye. All visible stars—all that existed, that is, for the early astronomers of the Mediterranean—were included in six magnitudes, the first containing the dozen or score of brightest stars in the heavens, the second perhaps twice as many ranking next to these, and so on out in gradually increasing circles. The work of the ancients has in this case been well preserved, no modern innovator having been found bold enough to disturb this time-honored system of reckoning. Still, as in the days of the "Father of Astronomy," the two chief stars of Orion serve as examples of the first magnitude, while his Belt and the Dipper in the northern sky furnish types of the second order. But, while astronomy was yet in its infancy, observers had noticed that the stars were not assorted into well-defined orders, in which all the individuals were equally bright; and so, in assigning to a star its magnitude, they would often add that it was "smaller" or "larger" than the mean of that magnitude. They thus practically trebled the number of their classes. The same division into thirds of a magnitude is still employed by those who judge of brightness by eye-estimates, though some are content with dividing into halves, and some undertake to be exact to tenths. Now, even though no scientific precision was attained, or even thought of, in this original apportionment of visible stars among the six magnitudes, to which all later estimates

are adjusted, we would expect to find one principle underlying such a classification, making it that of greatest convenience. It must be just as easy to tell a fourth magnitude star, for instance, from a fifth magnitude as from a third, and there must be as little doubt in distinguishing between the fifth and sixth magnitudes as between the third and second. The numbers expressing magnitudes, then, must actually represent a scale of equal differences as measured by the sensibility of the eye. When an astronomer pays attention to differences of luster, measured also by the sensibility of the eye, but closer than the founders of the science cared to notice, he naturally finds that he can distinguish the same number of intermediate grades between two adjoining magnitudes, whether faint or bright. Herschel's estimates, having been of this character, are, as we have seen, subject to the same condition.

The system of comparisons introduced by Herschel was not followed by later astronomers. Determinations of brightness in which accuracy is sought are now made by means of instruments constructed expressly for the purpose. These instruments, called photometers—measurers of light, that is, their office being to show the amount of light that one star gives as compared with others—add nothing to the discriminating power of the eye, it should be stated. In deciding a question as to which is the brighter of two stars, situated sufficiently near together, no appliance yet invented can assist. But they have these three advantages: they facilitate comparison between faint stars, they furnish a means of comparing distant stars as though side by side, and they give results in a numerical form. That is to say, we get by means of them a definite difference, which may be expressed as a fraction of a magnitude. The magnitude, we see, is no longer regarded as a class, but as a fixed point on a continuous scale; a striking example of that progress of science in all its branches from a qualitative to a quantitative stage, on which philosophers delight so to insist.

But how are measures of light to give us fractions of a magnitude? How can the vague, qualitative relation, the brighter the light the higher the magnitude, become an exact and quantitative one? The discussion of this question may be of use by showing that, even with matters of so uncertain a nature, science does not proceed by guesswork. It is a general law, that the human senses measure ratios and not differences. If I am carrying a small weight, for example, and the addition of an ounce is required to make the burden perceptibly heavier to me, two ounces will have to be added in order that I may notice a difference when I carry twice the weight, and a whole pound when I carry sixteen times the weight. Similarly with the other senses, and, in no slight degree, with the emotions as well. Sensibility to grief and joy, as the experience of every one will attest, becomes feebler with an increase of the amount sustained. So, a faint sound can be heard only in comparative silence, and our footsteps surprise us by their resounding din on the floor of an empty hall, though no louder,

as reflection easily assures us, than when the hall is filled with a bustling multitude. So, though the stars give us their whole light in the daytime, our eye, with the stimulus of an illuminated atmosphere, fails to discover them. This law, first stated by Fechner, is, in mathematical language, the excitement of a nerve varies in arithmetical progression as the exciting cause varies in geometrical progression, or degrees of sensation correspond to logarithms of the quantities perceived. Since, as just shown, the scale of magnitudes is that of equal differences in sensation, it must be at the same time that of equal ratios of light. We must thus have a constant light-ratio between each magnitude and the one next it, and these magnitudes must be logarithms of the quantities of light given, this ratio being taken as the base of our system. In fact, one of the first discoveries in photometry was that such a ratio actually exists; that, for example, if each star rated as third magnitude by good observers gives as much light as 2½ stars of the fourth magnitude, a star of the fourth equals 2½ of the fifth, and so on. Here was a practical confirmation of the character ascribed to ancient estimates of magnitude, and, at the same time, of Fechner's law.

This relation affords us the means of substituting exact measurement for estimates on an ill-defined scale by different observers, among whom a perfect agreement as to standard is out of the question. The idea that each observer has of the meaning of second or fifth magnitude is derived entirely from tradition and confirmed by habit, very much as are his notions of the significance of ordinary adjectives of degree—the only precaution observed being to alter the estimates of antiquity as little as possible, a vague limitation at best. Measures with the photometer depend no less on estimates with the eye, but the determination in them, as to the exact agreement of two lights, is subject to far less uncertainty.

Photometers agree in this particular, whatever their differences in mechanical construction. Seidel, of Munich, who was twelve years in comparing the light of but 208 fixed stars, used an apparatus where two stars seen through a telescope with divided object-glass, each out of focus, were made of the same brightness to the eye by diffusing or concentrating the light of one of them, its half of the object-glass being drawn out or in. The stars thus appeared as two disks, of different sizes but equally bright, and the amount of light given by each was taken as proportionate to the area covered by its disk. The same Dr. Zöllner who has lately become so conspicuous in "spiritualist" investigations, invented a much more convenient style of photometer, with which he made some interesting researches into the comparative light of the planets. Other astronomers, European and American, have also used it. With one of these instruments, belonging to the observatory of Harvard University, Mr. Peirce finished, a few years ago, perhaps the most extensive and methodical photometric work that

has yet been done. His measures included the visible stars, about five hundred in all, of the zone between 40° and 50° of north declination—those passing overhead in the Northern United States and Canada. The light of a kerosene lamp, in Zöllner's photometer, shines through a small round hole in a thin metallic plate, so as to form an imitation of a star, slightly brighter than the real stars with which it is compared. The light of this artificial star, having been polarized by passing through one Nicol prism, is partially cut off by turning another. The proportion of light so cut off depends on the angle of the second prism from parallelism with the first. Having thus found the amounts of light given by two or more stars, as compared with a fixed light, their differences of magnitude are calculated by applying the rule involving logarithms, alluded to above.

Owing to the labor involved in making any large number of photometric comparisons, the less accurate but more convenient method of eye-estimates has not yet been entirely superseded. It becomes necessary, then, to find some way of reducing different observers to one uniform scale, in order to have their work available for determination of variability and questions of distribution. Mr. Peirce, in his "Photometric Researches," recently published by the Harvard College Observatory, has shown that this may be done by the simple process of counting. When we find in any catalogue a star recorded as of magnitude $4\frac{1}{3}$, say, though we can not tell exactly what degree of brightness this figure denotes, we yet know something definite, namely, that this observer classes the star in question as fainter than those he calls 4 and brighter than those he calls $4\frac{2}{3}$. And we know something more: if in the northern hemisphere—a limited part of the heavens must be taken for the purpose, few catalogues being complete in southern stars—he classes 200 stars in all as brighter than $4\frac{1}{3}$, while he calls 25 stars $4\frac{1}{3}$ exactly, he means to tell us that his $4\frac{1}{3}$ magnitude stars would all fall between 200 and 225 on a list of northern stars arranged in order of brightness. It is by considering the order which stars would follow when so arranged, leaving entirely out of view the numbers by which their magnitudes are expressed, that Mr. Peirce brings all observers to a single standard of reference; for he is justified in assuming that each of them attaches the same idea of brightness to the 50th or 150th star in his order, as an assumption of some such nature must be made to have their estimates of any service at all. To reduce to magnitudes these numbers expressing order of arrangement, we have to notice that equal ratios among them correspond to equal differences in magnitude. If we take a good catalogue and find the number of stars in it brighter than 2·0, and add to this number successively the number between 2·0 and 3·0, 3·0 and 4·0, and so on, we shall find that our series of numbers increases geometrically, the common ratio being nearly $3\frac{2}{3}$. This is a remarkable fact, but it is not difficult to account for, on the supposition that the stars are uniformly scat-

tered throughout space, or that portion of space in which visible stars are situated. In this case, the number of them out to any distance from our solar system must vary as the cube of that distance, while their light, supposing no important variations in real size and brightness among them, is inversely proportionate, in the mean, to the square of their distance. And since we have a constant ratio of light between each magnitude and the next, we must accordingly have a constant ratio of mean distance, equal to the square root of this ratio inverted, and a constant ratio of number, equal to the cube of the ratio of distance. Mr. Peirce adopted the ratio $3\frac{2}{3}$. While introducing no perceptible change in the traditional magnitude-scale, except to rid it of irregularities, this number has the convenience of being exactly the cube of $1\frac{1}{2}$. Considering differences in brightness as due exclusively to differences in distance, we may conclude that a star of the second magnitude, for instance, is just half as far again from us as one of the first, and two thirds as far as one of the third. The magnitude of any star, then, is to be regarded as a logarithm of the number expressing its ordinal rank, $3\frac{2}{3}$ being the base of the system. We may thus find to what magnitudes the ordinal numbers, 200 and 225 in the example given, correspond, and take these as the superior and inferior limits of our observer's magnitude $4\frac{1}{2}$. The probable corrected magnitude may be considered as half way between these limits, and we can not be more exact than this in our reduction, because his discrimination has not been close enough to admit of it.

There are, it will thus be seen, three ways of stating the rank of the stars: by magnitudes or other devices to express differences of visual sensibility, by quantities of light, and by positions on a list arranged in order of decreasing luster. These three are reduced to one, through Fechner's law connecting the first two, and the hypothesis of equable distribution connecting the second and third.

But before accepting this hypothesis of equable distribution as part of our knowledge, we must see how well it agrees with the facts. Observation must determine if the "ratio of light" and the "ratio of number" have actually the mathematical relation given above. On the scale adopted by Mr. Peirce, as we have seen, the distance of a star should be two thirds that of one one magnitude fainter, and its light, by the law of the inverse square, $2\frac{1}{4}$ times as great. But the actual ratio of light between successive magnitudes is found by photometric measurement to be not far from $2\frac{1}{2}$; different observers varying from 2·3 to 2·8, but all giving values greater than the theory. By the fact, however, that the ratio thus found is constant or very nearly so for all grades of brightness, we are yet justified, notwithstanding the objection from its too high value, in determining magnitudes by counting, and so clearing individual estimates of much of their uncertainty and irregularity.

The conclusion seems unavoidable that a uniform distribution of

stars does not hold even in the region of space immediately about our solar system. Since the ratio of number is smaller than it should be to correspond to that of light, the density in which the stars are aggregated—if the expression be permitted—must diminish as the distance increases. Our sun is therefore in a part of space more closely filled than are neighboring parts. This is perhaps the most interesting result to which the study of photometry leads us, because it seems so strange at first sight—and even more strange when we remember that the nearest of the other suns is distant from us more than three years' journey of light. Truly, astronomy is without a rival in its special mission, to contradict on every point the evidence of superficial observation. We would most naturally suppose our universe to be as we are told it appeared to a distinguished visitor, when at once

> "The golden sun, in splendor likest heaven,
> Allured his eye; . . .
> . . . . where the great luminary,
> Aloof the vulgar constellations thick,
> That from his lordly eye keep distance due,
> Dispenses light from far."

But this appearance of standing aloof is wholly misleading, and, moreover, as our sun would rank by no means first among the fixed stars if placed at the distance of the nearest of them, and would sink below the third magnitude if removed as far as Sirius, its real insignificance in the stellar firmament is almost as striking as its supremacy in its own planetary system. The reflection is an interesting one, how lamentably the grandest of poems must have suffered had its author been compelled to regard the true proportions of the sidereal universe; but for the true lover of nature, it may be hoped, the glory of the Almighty handiwork will not be lessened through the disappearance from fancy of the universal sovereignty of the sun along the track made for it centuries ago by the vanished delusion that our earth was the unmoved center of all things.

It is very certain that an equable distribution could not hold throughout all space (for an infinite number of stars impartially scattered would, however vast the distances among them, give us a heaven shining like the sun in every part, with heat to correspond) unless, owing to the presence of innumerable dark bodies, or to a discontinuity in the luminiferous ether itself, as some physicists have suggested, light from remote distances is wholly or partly cut off before reaching us. But to this view, though it would agree with all the facts, that of a limitation of our firmament of stars, in extent and number, is generally preferred. That such a limitation exists we have other reasons for believing: prominent among these is the system of distribution which a census of the heavens brings to light. We could not expect

an infinite universe of stars to show everywhere such a uniformity of plan.

How the fixed stars are actually distributed through space, an inquiry into which we are led by study of their number and brightness, it has been but recently found worth while to consider. So long as they were believed to be simply lights set in a hollow revolving structure that divided the waters beneath from the waters above; so long as the idea of the "firmament" retained the association with solidity that now only remains in the word; so long as the "spangled heavens, a shining frame" was a reality of opinion and not an unmeaning archaism of poetry—this question was never heard. No significance could attach to it, and it excited no curiosity. But when this solid celestial framework was broken up by the discovery of the earth's rotation, and its lights scattered afar on the deep ocean of unbounded space, when contemplation of the beautiful adjustments and proportions of our solar system had suggested the hope of discovering the same harmonies throughout the universe, it began to be asked if some of these far-distant orbs, or perhaps the mighty whole, our sun and its attendant planets included, were not connected in a system of similar character. Kant was one of the first to advance this idea. The elder Herschel, contenting himself with a working hypothesis to give form to his observations, supposed our firmament to be a mighty cluster of stars equally distributed within finite limits, so that the number visible in the field of his great reflector at any pointing would show the extent of occupied space in that direction; and he undertook to gauge the depths and discover the shape of this cluster by counting telescopic fields in different parts of the sky. The elder Struve considered the density of the stars as varying with the distance from the Milky Way, as does that of the atmosphere with its distance from the earth's surface; being equal in parallel plans.* Argelander, of Bonn, relieved his laborious task of cataloguing over 300,000 northern stars, by investigation into the subject; Mr. Proctor has devoted to it numerous memoirs and popular lectures, and speaks of it as his chief incentive to the labor of constructing his set of twelve star maps; Mr. Peirce gives it considerable space in his "Photometric Researches." From these sources we have a few conjectures and a few facts.

The richest parts of the sky, in bright and faint stars alike, are almost all about the Milky Way. This stream of suffused light follows, with some irregularities, the course of a great circle; and toward the plane of this circle, passing not very far, perhaps, from the sun, stars at all distances appear to become more densely packed. The Milky Way itself is evidence of this for the faintest magnitudes; and Herschel's star-gauges, from which he inferred for our cluster the shape of a disk or lens, give the comparison in a numerical form.

* Professor Newcomb's account of these researches and speculations, in his "Popular Astronomy," pages 462–476, is full and interesting.

Argelander's gauges show the same concentration in telescopic stars brighter than the tenth magnitude, and it is even more plainly to be made out from Mr. Proctor's chart of his great catalogue. If parallel to the great circle of the Milky Way two small circles be passed, each at a distance from it of 30°, having between them a broad belt about the celestial sphere somewhat like the torrid zone on the earth's surface, we shall leave two spherical caps whose united area will exactly equal that of the belt — just one hemisphere. From Argelander's gauges it may be calculated that the number of stars inside these 30° circles is to that outside nearly as 2½ to 1, for stars of the ninth magnitude, and about as 2 to 1 for the eighth, diminishing with brighter stars. This condensation increases without interruption, to the Milky Way itself. The law holds also with stars visible to the naked eye, though not so conspicuously; for these, Mr. Peirce found the same ratio to be only as 4 to 3. He was also surprised to see that the stars were very little more numerous in the track of the Milky Way than at a distance of 20° from it, the decrease in density appearing almost suddenly about 30°. But as we approach the sun, the rate of condensation becomes greater again. Of the twenty stars classed as first magnitude by the best observers, fifteen are within the 30° circles; and of the five outside, but two, Arcturus and one far southern star, are equal in brightness to the average of the twenty. We have no right, however, unless we are dealing generally with a very great number of stars, to take light as a reliable indication of distance. Of our twelve nearest neighbors yet recognized, being all that have a parallax greater than one sixth of a second, and distant from us less than twenty years' journey of light, four are telescopic stars, to which attention was attracted by their large proper motion. Ten stars out of these twelve, it should therefore be added, are either in the Milky Way or within 15° of it. The exceptions are two minute stars in Ursa Major.

Will these facts enable us to decide what is the actual form of the immense cluster of stars in which our sun holds so humble a rank? We may conclude from them, with safety, that the strongly marked and surprising concentration of brightest and nearest stars in the galactic plane is irreconcilable with a generally prevailing uniform distribution, and agrees hardly better with Struve's theory of condensation in parallel planes. For this theory, it will be seen, requires a more decided concentration with a greater distance, the planes of equal density appearing to approach the galactic circle and each other as do the parallel lines of a perspective drawing. We do see some tendency of this kind in telescopic magnitudes, so that we might suppose that Struve's theory began to express the facts at the distance of the faintest visible stars—unless it could be shown that the density of aggregation in the central plane also varies at different distances. In Mr. Peirce's opinion, photometric observations have proved that this density increases from the seventh to the ninth magnitude, and that there-

fore the idea of the Milky Way itself as a vast ring of closest aggregation, including a more sparsely filled region, thus giving to the whole cluster, could it be seen laterally from a sufficient distance, an appearance not unlike that of the annular nebula in Lyra, is well founded. He also finds reason for supposing a similar but independent arrangement of the brightest stars, in the peculiar localization of the nearest of them, and the sudden falling off in density at about 30° from the galactic circle, above remarked—other systems of condensation requiring gradual changes. The true figure, if his reasoning is to be trusted, would therefore be a small ring of maximum density near the center of a very large one.* Such speculations are, however, it is hardly necessary to say, very uncertain.

It is not easy to make out, from the general distribution of the stars, that our sun is in one direction rather than another from the center of the sidereal system, and there is even some doubt about the position which some astronomers give us, on the northern side of the plane of the Milky Way. Indeed, beyond the prevailing condensation toward this plane, it seems that no important general law governing star aggregation has yet been found. Mr. Proctor's services in calling attention to the grouping of certain portions of the heavens in subordinate systems having a common "star-drift," should not be overlooked; but his discovery that a large part of the southern hemisphere is particularly rich in stars † can not be admitted for several reasons: 1. Behrmann's catalogue of southern stars, in which magnitudes were observed with particular care, shows nothing of the sort; 2. Mr. Proctor's own maps show nothing of the sort, for stars brighter than the sixth magnitude; and it is far less credible that an anomalous law of distribution holds over a wide area, affecting but this one order of brightness, than that those who observed this part of the heavens included more and fainter stars in their sixth magnitude than did northern observers; 3. Mr. Proctor's own maps show that the boundary of his "rich region" is the Tropic of Capricorn; and it is far less credible that an artificial circle should limit any law of distribution than that the whole difference is due to the fact that this tropic was also the northern boundary of La Caille's observations, the source, in all probability, whence the magnitudes of Mr. Proctor's stars were originally derived. Observers, in fact, are particularly likely to differ in estimating the extent of the sixth magnitude, for it seems to have been agreed by general consent that this magnitude shall include all stars to be seen with the unaided eye on the clearest nights, and differ-

* "Photometric Researches," pages 175–178. The sun, it would seem, is to be considered as in a region of exceptional rarity as compared with other regions through which the galactic plane passes, and at the same time of exceptional density when the comparison includes stars remote from this plane.

† Most positively stated in a lecture before the Royal Institution, May, 1870; also in the introduction to his "Star Atlas."

ences of climate and of individual eye-sight affect this considerably. Argelander, and after him Heis, catalogued all the stars visible to their eyes; their numbers, for the whole northern hemisphere, were 2,350 and 3,936 respectively. Heis, must therefore, have seen stars at least four tenths of a magnitude fainter than Argelander's faintest. La Caille's eye must also have been sharper than the average; and, if Mr. Proctor had thought to apply the test of enumeration to the different magnitudes in different parts of the sky, this explanation would doubtless have occurred to him, and nothing have been heard of his remarkable "rich region." His observation is valuable, certainly; but only by showing the undeveloped state of the whole subject, and the precautions necessary before venturing conclusions on it.

The search for a common center, about which the uncounted millions of stars composing the galactic cluster may revolve, has tempted many investigators, but it can not be said as yet to have proved altogether successful. Mädler, by calculations from the proper motions of stars in different parts of the heavens, sought to locate it among the Pleiades; some later astronomers have preferred the Sword of Perseus; Mr. Maxwell Hall has just decided, and informed the Astronomical Society of England, that the universe turns about the South Elbow of Andromeda. The proof advanced is always incomplete, resting on assumptions not generally admitted; and when we remember that the gravitative force exerted by the fixed stars on one another is so small that to keep the nearest of them from falling to the sun, supposing no counterbalancing attractions, an angular velocity of but one second of arc in eighty years is needed; that the proper motions to be explained are often far larger than this; that the distance of the attracting center must be many times that of the nearest fixed star; and that the heavens give no sign of any preëminent body or group of bodies to which we may ascribe the enormous attractive power necessary to control these motions—the skepticism of many astronomers as to the universal center seems excusable.

It must be admitted, then, that but little of the true character of our sidereal system is known to us, and that all speculation upon it rests as yet on a very insecure foundation. But, as the sudden development of spectrum analysis has shown, matters of pure conjecture to-day may become entirely settled to-morrow; and it may reasonably be hoped that the secrets of this domain, if due interest be taken in them, will not much longer elude the search of scientific explorers.

FOOD AND FEEDING.

By Sir HENRY THOMPSON.

II.

THE remainder of the second portion of my subject—viz., the preparation of food, which ought to have been concluded in the first paper—must appear, although in very brief terms, at the commencement of this. After which I shall proceed to consider the chief object of the present article, viz., the combination and service of dishes to form a meal, especially in relation to dinners and their adjuncts.

I think it may be said that soups, whether clear (that is, prepared from the juices of meat and vegetables only), or thick (that is, *purées* of animal or vegetable matters), are far too lightly esteemed by most classes in England, while they are almost unknown to the workingman. For the latter they might furnish an important, cheap, and savory dish; by the former they are too often regarded as the mere prelude to a meal, to be swallowed hastily, or disregarded altogether as mostly unworthy of attention. The great variety of vegetable *purées*, which can be easily made and blended with light animal broths, admits of daily change in the matter of soup to a remarkable extent, and affords scope for taste in the selection and combination of flavors. The use of fresh vegetables in abundance—such as carrots, turnips, artichokes, celery, cabbage, sorrel, leeks, and onions—renders such soups wholesome and appetizing. The supply of garden produce ought in this country to be singularly plentiful; and, owing to the unrivaled means of transport, all common vegetables ought to be obtained fresh in every part of London. The contrary, however, is unhappily the fact. It is a matter of extreme regret that vegetables, dried and compressed after a modern method, should be so much used as they are for soup, by hotel-keepers and other caterers for the public. Unquestionably useful as these dried products are on board ship and to travelers camping out, to employ them at home when fresh can be had is the result of sheer indolence or of gross ignorance. All the finest qualities of scent and flavor, with some of the fresh juices, are lost in the drying process; and the infusions of preserved vegetables no more resemble a freshly made odoriferous soup, than a cup of that thick, brown, odorless, insipid mixture, consisting of some bottled "essence" dissolved in hot water, and now supplied as coffee at most railway stations and hotels in this country, resembles the recently made infusion of the freshly roasted berry. It says little for the taste of our countrymen that such imperfect imitations are so generally tolerated without complaint.

The value of the gridiron is, perhaps, nowhere better understood than in England, especially in relation to chops, steak, and kidney.

Still it is not quite so widely appreciated as it deserves to be in the preparation of many a small dish of fish, fowl, and meat, to say nothing of a grilled mushroom, either alone or as an accompaniment to any of them. And it may be worth while, perhaps, remarking that the sauce *par excellence* for broils is mushroom ketchup; and the garnish cool lettuce, watercress, or endive. And this suggests a word or two on the important addition which may be made to most small dishes of animal food under the title of "garnish." Whether it be a small fillet, braised or roasted, or a portion thereof broiled; a fricandeau, or the choice end of a neck of mutton made compact by shortening the bones; or a small loin, or a dish of trimmed neck cutlets, or a choice portion of broiled rumpsteak; a couple of sweetbreads, poultry, pigeon, or what not—the garnish should be a matter of consideration. Whether the dish be carved on the family table, as it rarely fails to be when its head is interested in the *cuisine*, or whether it is handed in the presence of guests, the quality and the appearance of the dish greatly depend on the garnish. According to the meat, may be added with a view both to taste and appearance, some of the following—*purées* of sorrel, spinach, and other greens, of turnips, and of potatoes plain, in shapes, or in croquettes; cut carrots, peas, beans, endive, sprouts, and other green vegetables; stewed onions, small or Spanish; cucumbers, tomatoes, macaroni in all forms; sometimes a few sultanas boiled, mushrooms, olives, truffles. In the same way chestnuts are admirable, whole, boiled, or roasted, and as a *purée* freely served, especially in winter when vegetables are scarce; serving also as farce for fowls and turkeys. While such vegetables as green peas, French and young broad beans, celery and celeriac, asparagus, seakale, cauliflower, spinach, artichokes, vegetable marrows, etc., are worth procuring in their best and freshest condition, to prepare with especial care as separate dishes.

It is doubtful whether fish is esteemed so highly as an aliment as its nutritious qualities entitle it to be, while it offers great opportunity for agreeable variety in treatment. As a general observation, it may be said that in preparing it for table sufficient trouble is not taken to remove some portion of the bones; this can be advantageously done by a clever cook without disfiguring or injuring the fish. Sauces should be appropriately served: for example, the fat sauces, as *hollandaise* and other forms of melted butter, are an appropriate complement of hot boiled fish, while *mayonnaise* is similarly related to cold. These and their variations, which are numerous, may also accompany both broiled and fried fish, but these are often more wholesome and agreeable when served with only a squeeze of lemon-juice, and a few grains of the zest, if approved, when a fresh green lemon is not to be had, and it rarely can be here. But the juice of the mushroom is preferred, and no doubt justly, by some. Endless variations and additions may be made according to taste on these principles. But there

is another no less important principle, viz., that the fish itself often furnishes a sauce from its own juices, more appropriate than some of the complicated and not very digestible mixtures prepared by the cook. Thus "melted butter"—which is regarded as essentially an English sauce—when intended to accompany fish, should not be, as it almost invariably is, a carelessly made compound of butter, flour, and water; but in place of the last-named ingredient there should be a concentrated liquor made from the trimmings of the fish itself, with the addition of a few drops of lemon-juice, and strengthened if necessary from other sources, as from shell-fish of some kind. Thus an every-day sauce of wholesome and agreeable quality is easily made; it finds its highest expression in that admirable dish, the sole with *sauce au vin blanc* of the French, or, as associated with shell-fish, in the *sole à la normande*. Some fish furnish their own sauce in a still simpler manner, of which an illustration no less striking is at hand in the easiest but best mode of cooking a red mullet, viz., baking it, and securing the gravy of delicious flavor which issues abundantly from the fish, chiefly from the liver. as its only sauce.

Passing rapidly on without naming the ordinary and well-known service of cold meats, fresh and preserved, poultry and game, open or under paste in some form, to be found in profusion on table or sideboard, and in which this country is unrivaled, a hint or two relating to some lighter cold *entrées* may be suggested. It is scarcely possible to treat these apart from the salad which, admirable by itself, also forms the natural garnish for cold dishes. A simple aspic jelly, little more than the *consommé* of yesterday flavored with a little lemon-peel and tarragon vinegar, furnishes another form of garnish, or a basis for presenting choice morsels in tempting forms, such as poultry-livers, ox-palates, quenelles, fillets of game, chicken, wild fowl, fish, prawns, etc., associated with a well-made salad. On this system an enterprising cook can furnish many changes of light but excellent nutritious dishes.

On salad so much has been written, that one might suppose, as of many other culinary productions, that to make a good one was the result of some difficult and complicated process, instead of being simple and easy to a degree. The materials must be secured fresh, are not to be too numerous and diverse, must be well cleansed and washed without handling, and all water removed as far as possible. It should be made by the hostess, or by some member of the family, immediately before the meal, and be kept cool until wanted. Very few servants can be trusted to execute the simple details involved in cross-cutting the lettuce, endive, or what not, but two or three times in a roomy salad-bowl ; in placing one saltspoonful of salt and half that quantity of pepper in a tablespoon, which is to be filled three times consecutively with the best fresh olive-oil, stirring each briskly until the condiments have been thoroughly mixed, and at the same time

distributed over the salad. This is next to be tossed well, but lightly, until every portion glistens, scattering meantime a little finely chopped fresh tarragon and chervil, with a few atoms of chives, over the whole. Lastly, but only immediately before serving, one small tablespoonful of mild French vinegar is to be sprinkled over all, followed by another tossing of the salad.* The uncooked tomato, itself the prince of salads, may be sliced and similarly treated for separate service, or added to the former, equally for taste and appearance. Cold boiled asparagus served with a *mayonnaise* forms a dish, of its kind, not to be surpassed. At present ranking, when the quality is fine, as an expensive luxury, there is no reason why, with the improved methods of cultivating this delicious and wholesome vegetable, it should not be produced in great abundance, and for less than half its present price.† As to the manifold green stuffs which, changing with the season, may be presented as salad, their name is legion ; and their choice must be left to the eater's judgment, fancy, and digestion, all of which vary greatly.

The combination of dishes to form a meal now demands our consideration. The occupations of man in a civilized state, no less than the natural suggestions of his appetite, require stated and regular times for feeding. But the number of these set apart in the twenty-four hours differs considerably among different peoples and classes. Taking a general view of the subject, it may be said that there are three principal systems to which all varieties of habit may be reduced. From an English point of view, these may be regarded as—

1. The Continental system of two meals a day.
2. The system of provincial life (Great Britain), or four meals.
3. The system of town life (Great Britain), or three meals.

1. In the Continental system, the slight refreshment served in the early morning, in the form of coffee or chocolate, with a rusk or a morsel of bread, does not amount to a meal. It is only a dish, and that a light one, and not a combination of dishes, which is then taken. At or about noon a substantial meal, the *déjeuner*, is served ; and at six or seven o'clock, an ample dinner. Such is the two-meal system, and it appears to answer well throughout the west and south of Europe.

2. What I have termed the provincial system consists of a substantial breakfast at eight or nine, a dinner at one or two, a light tea about five, and a supper at nine or ten. It is this which is popular throughout our own provincial districts, and also among middle-class society of our northern districts throughout both town and country. The habits also of the great German nation correspond more to this than to the first-named system.

* A salad for five or six persons is supposed.

† On this subject, and also on salad culture, see "The Parks and Gardens of Paris," by W. Robinson, F. L. S., p. 468, *et seq.*, second edition. Macmillan, 1878.

3. The prevailing system of London, and of the numerous English families throughout the country whose habits are formed from partial residence in town, or by more or less intimate acquaintance with town life, is that of three meals daily. In general terms the breakfast takes place between eight and ten; the lunch from one to two; the dinner from half-past six to eight.

In all cases each meal has its own specific character. Thus, here, breakfast is the most irregular in its service, and least of all demands general and intimate coherence of the party assembled. Individual interests concerned in the letter-bag, in the morning news, in plans for the day, in cares of coming business, etc., are respected. Provision for acknowledged dietetic peculiarities on the part of individuals is not forgotten, and every one comes or goes as he pleases.

At lunch the assembly is still somewhat uncertain. Thus some members of the family are absent without remark; intimate friends may appear without special invitation; while those less intimate can be asked with small ceremony. Occupations of pleasure or of business still press for pursuit during the afternoon, and the meal for such may not be too substantial. It should suffice amply to support activity; it should never be so considerable as to impair it.

The last meal of the three, dinner, has characters wholly different from the preceding. The prime occupations of the day are over; the guests are known and numbered; the sentiment is one of reunion after the dispersion of the day—of relaxation after its labors, sports, or other active pleasures. Whatever economy of time may have been necessary in relation to the foregoing meals, all trace of hurry should disappear at dinner. A like feeling makes the supper of the "provincial" system a similarly easy and enjoyable meal. And all this is equally true of dinner, whether it unites the family only, or brings an addition of guests. General conversation: the events and personal incidents of the day, the current topics of the hour, are discussed in a light spirit, such as is compatible with proper attention to the dishes provided. All that follows late dinner should for the most part be amusement—it may be at the theatre, an evening party, or a quiet evening at home. There should be ample time, however, for every coming engagement, and security for some intervening rest for digestion. Dinner, then, is the only meal which—as the greater includes the less—need be discussed in the third part of our subject, which claims to treat of custom and art in combining dishes to form a repast. With the requirements and under the circumstances just specified, it should not be a heavy meal, but it should be sufficing. No one after dinner should feel satiety or repletion, with a sense of repugnance at the idea of eating more; but all should still enjoy the conviction that a good meal furnishes delightful and refreshing occupation.

Dinners are of two kinds—the ordinary meal of the family, and the dinner to which guests are invited. There is a third dinner in

this country, of common—too common—occurrence, viz., the public dinner, which is essentially a British institution, and can not be passed by in silence.

The late dinner should never include children. It is a meal which is in every way unsuited to them, and they are quite unfitted to take part in its functions ; besides, the four-meal system is better adapted to their requirements of growth and digestion in early life. A family dinner may usually consist of a soup, fish, *entrée*, roast, and sweet ; the *entrée* may even be omitted ; on the other hand, if the meal is required to be more substantial, a joint may be served in addition after the fish ; but this should be very rarely necessary. A dish of vegetables may be advantageously placed before or after the roast, according to circumstances ; and supplementary vegetables should be always at hand.

The *rationale* of the initial soup has often been discussed : some regard it as calculated to diminish digestive power, on the theory that so much fluid taken at first dilutes the gastric juices. But there appears to be no foundation for this belief ; a clear soup, or the fluid constituents of a *purée*, disappear almost immediately after entering the stomach, being absorbed by the proper vessels, and in no way interfere with the gastric juice which is stored in its appropriate cells ready for action. The habit of commencing dinner with soup has without doubt its origin in the fact that aliment in this fluid form—in fact, ready digested—soon enters the blood and rapidly refreshes the hungry man, who, after a considerable fast and much activity, sits down with a sense of exhaustion to commence his principal meal. In two or three minutes after taking a plate of good warm *consommé*, the feeling of exhaustion disappears, and irritability gives way to the gradually rising sense of good-fellowship with the circle. Some persons have the custom of allaying exhaustion with a glass of sherry before food—a gastronomic no less than a physiological blunder, injuring the stomach and depraving the palate. The soup introduces at once into the system a small installment of ready-digested food, and saves the short period of time which must be spent by the stomach in deriving some portion of nutriment from solid aliment, as well as indirectly strengthening the organ of digestion itself for its forthcoming duties. Few will be found to dispute the second place in order to fish, although this arrangement is in some quarters an open question : its discussion, however, can scarcely be regarded as within the limit of our space. The third dish should consist of the chief meat, the joint, if desired ; if not, one of the smaller dishes of meat, such as fricandeau, cutlets, *filet*, or sweetbread, before spoken of, well garnished, will be appropriate, and to many preferable. Next the well-roasted bird—of game or poultry—accompanied or followed by salad, and a dish of choice vegetables. Then one light simple sweet, for those who take it, and a slight savory biscuit or morsel of

cheese completes the repast. Such a meal contains within its limits all that can be desired for daily enjoyment and use. If well and liberally served, it is complete in every sense of the word. Dessert and its extent is a matter of individual taste; of wines, coffee, and liqueurs I shall speak hereafter.

A word about *hors-d'œuvres*. It is well known that the custom exists to a very wide extent among Continental nations of commencing either mid-day *déjeuner* or dinner by eating small portions of cold pickled fish, vegetables, of highly-flavored sausage thinly sliced, etc., to serve, it is said, as a whet to appetite. This custom reaches its highest development in the *zakuska* of the Russian, which, consisting of numerous delicacies of the kind mentioned, is sometimes to be found occupying a table in an anteroom to be passed between the drawing-room and dining-room; or, and more commonly, spread on the sideboard of the latter. The Russian eats a little from three or four dishes at least, and "qualifies" with a glass of strong grain-spirit (*vodka*) or of some liqueur before taking his place at the table. Among these savory preliminaries may often be found caviare in its fresh state, gray, pearly, succulent, and delicate, of which most of the caviare found in this country is, speaking from personal experience of both, but as the shadow to the substance.

I have no hesitation in saying, after much consideration of the practice of thus commencing a meal, that it has no *raison d'être* for persons with healthy appetite and digestion. For them, both pickled food and spirit are undesirable, at any rate on an empty stomach. And the *hors-d'œuvres*, although attempts to transplant them here are often made, happily do not, as far as I have observed, thrive on our soil. They have been introduced here chiefly, I think, because their presence, being demanded by foreign gastronomic taste, is supposed to be, therefore, necessarily correct. But the active exercise and athletic habits of the Englishman, his activity of body and mind in commercial pursuits, all tend to bring him to the dinner-table wanting food rather than appetite, and in no mind to ask for "whets" to increase it. Among idle men, whose heavy lunch, liberally accompanied with wine and not followed by exercise, has barely disappeared from the stomach at the hour of dinner, a piquant prelude as stimulus of appetite is more appreciated. Hence the original invention of *hors-d'œuvres;* and their appearance in a very much slighter and more delicate form than that which has been described, still to be observed in connection with the chief repasts of the Latin races. The one plate which heralds dinner, indigenous to our country, is also one of its own best products—the oyster. But this is scarcely a *hors-d'œuvre*. In itself a single service of exquisite quality, served with attendant graces of delicate French vinegar, brown bread and butter, and a glass of light chablis for those who take it, the half-dozen natives occupying the hollow shells, and bathed in their own liquor, hold rank of a very

different kind to that of a miscellaneous assortment of tidbits alluded to. Oysters are, in fact, the first dish of dinner and not its precursor; the first chapter, and not the advertisement. And this brings us to the dinner of invitation.

And of this dinner there are two very distinct kinds: First, there is the little dinner of six or eight guests, carefully selected for their own specific qualities, and combined with judgment to obtain an harmonious and successful result. The ingredients of a small party, like the ingredients of a dish, must be well chosen to make it "complete." Such are the first conditions to be attained in order to achieve the highest perfection in dining. Secondly, there is the dinner of society, which is necessarily large; the number of guests varying from twelve to twenty-four.

The characteristics of the first dinner are—comfort, excellence, simplicity, and good taste. Those of the second are—the conventional standard of quality, some profusion of supply, suitable display in ornament and service.

It must be admitted that, with the large circle of acquaintances so commonly regarded as essential to existence in modern life, large dinners only enable us to repay our dining debts, and exercise the hospitality which position demands. With a strong preference, then, for the little dinners, it must be admitted that the larger banquet is a necessary institution; and therefore we have only to consider now how to make the best of it.

No doubt the large dinner has greatly improved of late; but it has by no means universally arrived at perfection. Only a few years ago excellence in quality and good taste in *cuisine* were often sacrificed in the endeavor to make a profuse display. Hence, abundance without reason, and combinations without judgment, were found coexisting with complete indifference to comfort in the matters of draughts, ventilation, temperature, and consumption of time. Who among the diners-out of middle age has not encountered many a time an entertainment with some such programme as the following: one of an order which, it is to be feared, is not even yet quite extinct?—

Eighteen or twenty guests enter a room adapted at most to a dinner of twelve. It is lighted with gas; the chief available space being occupied by the table, surrounding which is a narrow lane, barely sufficing for the circulation of servants. Directly—perhaps after oysters—appear turtle soups, thick and clear. A *consommé* is to be had on demand, but so unexpected a choice astonishes the servitor, who brings it after some delay, and cold; with it, punch. Following, arrive the fish—salmon and turbot, one or both, smothered in thick lobster sauce: sherry. Four *entrées* promenade the circuit in single file, whereof the first was always oyster patties; after which came mutton or lamb cutlets, a vol-au-vent, etc.: hock and champagne. Three quarters of an hour at least, perhaps an hour, having now elapsed,

the saddle or haunch of mutton arrives, of which gentlemen who have patiently waited get satisfactory slices, and currant jelly, with cold vegetables or a heavy, flabby salad. Then come boiled fowls and tongue, or a turkey with heavy forcemeat; a slice of ham and so on, up to game, followed by hot, substantial pudding, three or four other sweets, including an iced pudding; wines in variety, more or less appropriate; to be followed by a *pâté de foie gras*, more salad, biscuits and cheese. Again, two ices, and liqueurs. Then an array of decanters, and the first appearance of red wine; a prodigious dessert of all things in and out of season, but particularly those which are out of season, as being the more costly. General circulation of waiters, handing each dish in turn to everybody, under a running fire of negatives, a ceremonial of ten or fifteen minutes' duration, to say the least. Circulation of decanters; general rustle of silks, disappearance of the ladies; and first change of seat, precisely two hours and a half after originally taking it. It may be hoped that a charming companion on either side has beguiled and shortened a term which otherwise must have been felt a little long. Now the general closing up of men to host, and reassembling of decanters; age and qualities of wine, recommendation of vintages. Coffee which is neither black nor hot. Joining the ladies; service of gunpowder tea, fatal to the coming night's rest if taken in a moment of forgetfulness; and carriages announced.

Admitted that such an exhibition is impossible now in any reasonable English circle, it nevertheless corresponds very closely in style with that of the public dinner; a state of things without excuse. And the large private dinner is still generally too long, the *menu* too pretentious. Let me, however, be permitted to record, equally in proof of growing taste and as grateful personal duty, how many admirable exceptions to the prevailing custom are now afforded. Then, of course, it must be understood that, while the dinner for six or eight persons is designed as an harmonious whole of few, well-chosen dishes, all of which are intended to be eaten in their order, the *menu* of the larger party must offer various dishes for choice to meet the differing tastes of more numerous guests, and it must therefore be larger. Let us see how this is to be met. First, the soups: it is the custom to offer a *consommé*, which ought to be perfect in clearness, color, and savor, and to be served perfectly hot; containing vegetables, etc., variously treated—doubtless the best commencement, as it is the keynote, of the dinner; revealing also, as it does nine times out of ten, the caliber of the cook to whose talent the guest is intrusted. But there is mostly an alternative of "white soup," and this is almost always a mistake. Many persons refuse it, and they are right, containing, as it generally does, a considerable proportion of cream—an injudicious beginning, when there is much variety to follow; excellent sometimes as one of three or four dishes, but dangerous otherwise to the guest who has not an exceptionally powerful digestion. But, sup-

pose oysters, vinegar, and chablis have just been swallowed! A brown *purée*, as of game, or one of green vegetables, less frequently met with, would be far safer. Two fish, of course, should always be served; as, for example, a slice of Severn or Christchurch salmon, just arrived from the water, for its own sake; and a fillet of white fish for the sake of its sauce and garnish, which should be therefore perfect. The next dish is, in London, a question under discussion, viz., the question of precedence to an *entrée*, or to the *pièce de résistance*. The custom has been to postpone the appearance of the latter until lighter dishes have been dispatched or declined. If, however, the English joint is required at a meal already comprehensive in the matter of dishes, and taken at a late hour, it seems more reasonable to serve it next to the fish, when those who demand a slice of meat may be expected to have an appropriate appetite, which will certainly be impaired, equally by accepting the *entrées*, or fasting partially without them. After the joint, two light *entrées* may follow, and these must necessarily be either in themselves peculiarly tempting morsels, or products of culinary skill, offering inducement to the palate rather than to an appetite which is no longer keen. Then the best roast possible in season, and a salad; a first-rate vegetable, two choice sweets, one of which may be iced; a light savory biscuit or a morsel of fine barely salted caviare, which may be procured in one or two places at most in town, will complete the dinner. For dessert, the finest fruits in season to grace the table and for light amusement after; or simply nuts in variety, and dry biscuits; nothing between the two is tolerable, and little more than the latter is really wanted; only for decorative purposes fruit equals flowers. But it may be admitted that the diminished number of sweet *entremets* strengthens the plea for a supply of delicious fruits, rendering the dessert useful and agreeable as well as ornamental.

And, now that dessert is over, let me say that I do not admit the charge sometimes intimated, although delicately, by foreigners, of a too obvious proclivity to self-indulgence on the part of Englishmen, in permitting the ladies to leave the table without escort to the drawing-room. The old custom of staying half an hour, or even an hour afterward, to drink wine, which is doubtless a remnant of barbarism, has long been considered indefensible. Still, the separation of the party into two portions for fifteen or twenty minutes is useful to both, and leads perhaps more completely to a general mixture of elements on reunion after than is attained by the return of the original pairs together. Whether this be so or not, the ladies have a short interval for the interchange of hearsays and ideas relative to matters chiefly concerning their special interests; while the men enjoy that indispensable finish to a good dinner, an irreproachable cup of coffee and a cigarette, and the sooner they arrive the better. With the small dinners of men it can scarcely too quickly follow the last service.

But marked by a special character are some dinners, which may be either small or large, in relation to the number of guests, but which are necessarily limited as regards the variety of aliments served. I refer to dinners at which either turtle or fish predominates. In accordance with a principle already enunciated, a bowl of substantial stock, containing four or five broad flakes of the gelatinous product, often miscalled "fat," which alone represents the turtle in the compound, is not a judicious prelude to a dinner arranged according to the orthodox programme, and offering the usual variety. A lover of turtle indulges freely in the soup, both thick and clear, making it in fact an important installment of his repast; and he desires, with or without some slight interlude, to meet the favorite food again in the form of an *entrée*. After so substantial a commencement, the dinner should be completed chiefly by poultry, and game if in season, and for the most part by dishes which are grilled or roast, in contrast to the succulent morsels which have preceded.

The fish dinner, also an occasional departure from daily routine, is acceptable, and gratifies the taste for that delicate and pleasant food in considerable variety. But, if so indulged, very few dishes ought to appear subsequently. It is a curious fact that the traditional bacon and beans, which appear toward the close of a Greenwich whitebait dinner, should afford another illustration of undesigned compliance with the natural law referred to at the outset, the bacon furnishing complementary fat to supply its notable absence in fish.

The enjoyment of a curry—and when skillfully made it is almost universally admitted to be one of the most attractive combinations which can be offered to the senses of taste and smell—is only possible at a limited repast. When freely eaten, very little is acceptable to the palate afterward, exhausted as it is by the pervading fragrance of the spice and other adjuncts. Hence a curry should form the climax of a short series of dishes leading up to it: when presented, as it sometimes is, among the *entrées* of a first course, it is wholly out of place.

Here we may appropriately take a rapid glance at the characteristics of the feast where the guests are few in number.

The small dinner-party should be seated at a round or oval table, large enough for personal comfort, small enough to admit of conversation in any direction without effort. The table should of course be furnished with taste, but is not to be encumbered with ornaments, floral or other, capable of obstructing sight and sound. A perfect *consommé*, a choice of two fish, a *filet* or a châteaubriand, a *gigot* or a fricandeau; followed by a chaudfroid, a *crème de volaille garni*, a roast and salad, a choice vegetable, and an iced *soufflé* or *charlotte;* and in summer a *macédoine* of fresh fruits in an old china family bowl, if there is one; and, lastly, a savory biscuit, accompanying vegetables and appropriate wines, may be regarded as furnishing a

scheme for such a party, or a theme of which the variations are endless. Seven or eight guests can thus be brought into close contact: with a larger number the party is apt to form two coteries, one on each side of the host. The number is a good one also in relation to the commissariat department—eight persons being well supplied by an *entrée* in one dish; while two are necessary for ten or twelve. Moreover, one bottle of wine divides well in eight; if, therefore, the host desire to give with the roast one glass of particularly fine ripe Corton or Pomard, a single bottle is equal to the supply; and so with any other choice specimen of which a single circulation is required; and of course the rule holds equally if the circuit is to be repeated.

And this leads us to the question—and an important one it is—of the wine.—*Nineteenth Century.*

DRY-ROT IN TIMBER.*

NEARLY everybody has heard of dry-rot, and knows that it is something which causes the destruction of wood in a manner different from ordinary decay. Some suppose the effect to be due to peculiar insects that gnaw timber to powder, and others have no very definite notions as to what produces it. Carpenters, ship-builders, lumbermen, and house-owners often find, by the rapid destruction of their property, that, whatever its cause, it is a very serious matter, and they seek to be protected from the evil, though taking little pains to inform themselves of its real nature and conditions. The subject is, however, one of curious scientific interest, and has now come to be pretty well understood. An excellent work upon it has recently been compiled by Mr. T. A. Britton, an eminent British architect, who has ransacked all sources of information; and for the materials of the statements which here follow we are indebted to this book.

To understand the nature and effects of dry-rot we must first glance briefly at the structure and properties of wood. The mass of the trunks of timber-trees consists of slender, short fibers, with tapering ends, which overlap each other; but this overlapping does not prevent the passage of sap through them. At first these fibers are hollow, but are gradually filled by the deposition of solid matter from the sap within them. The strength of wood is due to the shortness and overlapping of the fibers, and to the presence of this deposit. Woody fiber pervades the tree from the tips of the roots to the extremities of the branches, and is the chief organ of circulation. A current of sap passes upward through it, from the roots to the leaves; and another

* A Treatise on Dry-Rot in Timber. By Thomas Allen Britton. London and New York: E. & F. N. Spon.

current, containing the products of leaf-action, passes back from the leaves, and is distributed for the uses of the tree. As wood grows older it grows darker, particularly in the center of the stem or heart. This darkening is due to the deposit within the fibers; and when a tree reaches maturity the fibers are so filled as no longer to join in the general circulation. Now, this inner or heart wood is less liable to decay than the outer or sap wood, and sap, as is well known, is the agent of destruction. Sap is water with sugary, saline, albuminous, mucilaginous, and gummy matters dissolved in it, and such solutions ferment easily and rapidly. Fermentation is a state of vegetable matter in which the various molecules, sugary, oily, albuminous, etc., exert their peculiar attractive and repulsive powers, forming new combinations, which at first change and at length destroy the texture of the substance of which they were formerly a part. Every one knows the smell of pure, fresh wood. If you bore into wood in which the sap has just begun to ferment, you get a vinous smell, which is soon followed by the smell of putrefactive decay, unless means are taken to arrest the chemical changes that are in progress. This decomposition of wood containing sap is ordinary rot or wet-rot. It is the most general and the most fatal cause of decay in wood; but it has attracted less attention than the more startling but less common evils of dry-rot, and the destruction of timber by insects.

The *seasoning* of wood, whether naturally or artificially, is simply the evaporation of its sap. Decay can not occur in well-seasoned wood if it is kept dry. It matters little whether wet is applied to timber before or after the erection of a building: it can not resist the effect of what must arise in either case; for heat and moisture will produce putrid fermentation. In basement stories with damp under them, dry timber is but little better than wet, for if it is dry it will soon be wet, and decay will only be delayed while the timber is absorbing moisture; and the amount it receives will depend upon the closeness of the deposit within its fibers. This moisture dissolves the substances held in solution by the sap, and fermentation begins, with its usual train of consequences.

Dry-rot is one of these consequences. Ordinary decay must have begun before dry-rot sets in. When the moisture in wood begins to ferment, whether it be the natural sap, or the water absorbed by seasoned timber, the conditions are ripe for the inroads of dry-rot, which can no more occur without moisture than wet-rot. The immediate agent of destruction, in this case, is of vegetable origin. It takes its name from the dust to which it reduces timber. That degree of moisture which is favorable both to natural decay and to the growth of plants is essential to the process of dry-rot. The vegetation that produces it belongs to the natural group of fungi. This group is made up of plants having distinct vegetative and reproductive systems, and their best known representative is the common mushroom. If you ex-

amine the mold on which this singular plant is seen to grow, you will find it penetrated with delicate, whitish, interlacing filaments which are the vegetative system of the plant. This part of a mushroom is called the *mycelium*, and from it arises the reproductive portion which grows above ground. But the only part of this above-ground portion that is essential, and that is found in all fungi whatever, is just that part which escapes ordinary observation. Everybody has seen the umbrella-like cap with the radiating vertical plates on its under surface. These plates are covered by a membrane which has the same office as the seed-vessel of the higher plants. It bears the minute reproductive bodies of the fungi, analogous to common seeds, and called spores.

The only parts of a mushroom which are common to all fungi are the mycelium or thready, interlacing portion which grows underground, and the minute, microscopic spores which are cellular in structure and so small that thousands of them are required to form a body the size of a pin's head. The fungi differ among themselves in many ways; but mycelia and spore production always occur in them, and are their essential characters. Every plant of which this mycelium forms a part, spreading its web throughout the substance on, or in, which it grows, belongs among fungi. Most of the species are either quite invisible, or else their parts are so small as to be indistinguishable. But some sort of reproductive organs exist, and spores are always produced. The mycelium is often so minute as to traverse living plants and the pores of solid wood. It grows rapidly and causes quick decay. Potato-rot, the yeast- and vinegar-plants, mildews, rusts, and smuts of grain, and molds of all kinds, are part of this immense group of plants that lives upon decay and fills the air with its countless myriads of spores. These subtile, germinal particles are lodged everywhere. They are light as vapor and abound in air, in water, in dust, in sand, ready, when warmth and moisture favor, to burst into life. As has been said, the dry-rot fungi flourish upon the products of wet-rot. Different stages of decay produce food of different qualities, adapted to different species of fungi. One species takes up the process where another leaves it, and carries it further and further forward.

Dry-rot may begin its ravages in the interior of timber as easily as upon the surface. As atmospheric dust is filled with the spores of fungi, they may be conveyed by rain into the earth, absorbed by the roots of vegetables, and diffused with the sap throughout the whole plant. There are numerous species of dry-rot fungi adapted to different conditions of life and presenting different aspects. Nor are they restricted to timber. They may flourish in the earth, where they present a perfectly white mycelium, branching and interlacing like roots; and when workmen are employed on grounds which are affected by the dry-rot fungi their health is often disturbed. A few years since, while a London builder was putting up some houses at Hampstead, his men were never well. He afterward learned that the ground was affected

by rot, and that, within one year after the house was erected, all the basement floor was in a state of premature decay. In cases of dry-rot, where the mycelium passes through substances from the external surface, it separates into innumerable small branches; when it proceeds from slime in the fissures of the earth, the mycelial fibers shoot in every direction and are very much tangled. Arising from the roots of trees, they look at first like hoar frost, but soon show regular toadstools. When they grow in very damp situations, they feel fleshy and extend equally around a circular space which they wholly cover unless obstacles interpose.

Excessive damp is unfavorable to this fungus, and its growth is more rapid in proportion as the situation is less damp, until the proper point for the growth of vegetation is reached. When the fungus extends to dry situations, its effects are more destructive to the timber on which it grows: it is very fibrous, and in part covered with a light-brown membrane perfectly soft and smooth. It is often of great magnitude, projecting from the timber in a white spongeous excrescence, on the surface of which a profuse humidity is frequently observed. Sometimes it forms only a fibrous, thin-coated, irregular web on the surface of the wood. Excrescences of a fungiform appearance are often protruded amid those already described, and are evidences of a very corrupt state at the spots whence they spring. Sometimes they arise in several fungiforms, each above the other, without any distinction of stem; and in some corrupt states the small acrid mushroom is generated.

But there are two or three species of fungi that are chiefly concerned with the process of dry-rot. The *Merulius lachrymans* (often called *the* dry-rot) is a most formidable enemy of timber. When the section of a piece of wood attacked internally by dry-rot is examined through a microscope, and minute white threads are seen interlaced and matted together all through its substance, and when this cottony texture effuses itself over the surface of the timber, and in the center of it a gelatinous substance forms which gradually becomes tawny and wrinkled and sheds a red powder on the white, downy surface, you have the *Merulius lachrymans*. But, long before this last stage of growth is reached, the interior of the wood has perished. As soon as the cottony filaments are seen upon timber internally affected, we may be sure that an apparently solid beam may be crumbled to dust between the fingers. In his botanical description of this plant, Dr. Greville says it is "soft, tender, at first very light, cottony, and white; veins appear, at length, which are of a fine orange or reddish brown, forming irregular folds, usually so arranged as to appear like pores, but never anything like tubes, *and, when perfect, distilling drops of water.*" Hence the term *lachrymans*. The folds or pores here spoken of are the reproductive portion of the plant. They are covered by the hymenium or spore-bearing membrane, which sheds its red powder

upon the white mycelium. In this fungus the stem is entirely absent, and the cap is attached by its back. In the different species we may find the reproductive or spore-bearing portion in the form of a cup, or a goblet, or a saucer; of an ear, a bird's nest, a horn, a bunch of coral, a button, a rosette, a lump of jelly, or a piece of velvet. The *Merulius* is found in cellars and hollow trees, sometimes several feet in width.

Another fungus, the *Polyporus hybridus*, is an especial enemy of oak-timber. It is described by Berkley as "white, mycelium thick, forming a dense membrane or creeping branched strings; hymenium breaking up into areæ, pores long, slender, minute." This species makes great havoc in the navy. At one time it is said, in the memoirs of Pepys, thirty new wooden ships in the British navy, "for want of proper care and attention, had toadstools growing in their holds as big as one's fists, and were so decayed that the planks dropped from their sides." In the beginning of this century, three 74-gun ships of the Royal Navy decayed in five years; three others in seven years; and a 100-gun ship in six years. Fungi have been seen growing between the timbers of a man-of-war strong enough to force a plank half an inch from the ship's side.

But, without attempting to discriminate among the fungi causing dry-rot, it may be stated generally that, in timber that has been only superficially seasoned, this disease often arises internally, and has been known to convert the entire substance of a beam, excepting an inch or two at the surface, into fine, white, and thread-like vegetation, which forms a thick, fungous coat at the ends of the beam, otherwise appearing perfectly sound. This has often been observed in large girders of yellow fir, which have seemed sound on the outside. Major Jones, R. E., states of a building in Malta, that "the timbers had every external appearance of being sound, but on being bored with an auger they were found internally in a total state of decay."

The first symptoms of dry-rot in timber are swelling, discoloration, moldiness, and a musty smell. As the disease advances the fibers shrink lengthwise and break, presenting many deep fissures across the wood; finally, the cohesion of the wood is utterly destroyed, and at the least disturbance it crumbles to powder. Before it has time to destroy the principal timbers in a house, it gets behind the skirtings, dadoes, and wainscotings, drawing in the edges of the boards, and splitting them both horizontally and vertically. When cleared of the fungus they look like wood that has been charred. Though affected but a short time, a slight pressure will break them asunder: and, when examined, the fibrous fungus will be seen closely attached to the decayed wood.

Timber that is floated down rivers and conveyed from place to place in ships is very liable to this disease. It is said of the exports of timber from Canada to England, that few cargoes in the log arrive

in which, in one part or other of almost every log, you will not see the beginning of this rot, either as reddish, discolored spots, which, when scratched by the nail, show that the texture to some little depth has been reduced to powder, or else the white fibers themselves may be seen growing. If the cargo was shipped dry, and had a rapid passage, the case is not so bad; but when shipped wet, and the voyage has been prolonged, white fibers will be seen growing over nearly every part of the surface of every log, especially if they are of yellow pine, red pine, and oak.

When *deal* (pine planks) is shipped wet in Canada, it is also covered with a network of white fibers on its arrival in England, and even when shipped tolerably dry the fungus will be found upon some of the pieces. When they have been floated down our rivers and shipped as soon as they were taken from the water, at the end of the voyage they are often so covered with this network of mycelial fibers that force is necessary to separate them, and they will grow together again in the barges before being landed. If deals in this state are piled flatwise, a whole pile will become deeply affected with rot in six months. In some instances the rot penetrates to the depth of one eighth of an inch. The decay may be arrested by sweeping the surface of each deal, and repiling them upon their edges during dry weather. The ships which carry this timber, though built of good, sound, well-seasoned oak, must be carefully dealt with, or they will become affected. It is usual to scrape their surface as soon as they are clear of the cargo, and sometimes the hold is washed with a desiccating fluid. The effects of dry-rot upon European deals are very similar to those exhibited by Canadian deals. Decay is more rapid in white deal than in yellow, for the white deal absorbs more water than yellow deal. In the same way yellow deal absorbs more water and decays faster than red deal.

An example of the rapid decay of timber from dry-rot was given by Sir Thomas Deane in 1849 before the Institution of Civil Engineers in Ireland. It occurred in the Church of the Holy Trinity at Cork. On opening the floors under the pews, a most extraordinary appearance presented itself. There were flat fungi of immense size and thickness, some so large as almost to occupy a space equal to the size of a pew, and from one to three inches thick. In other places fungi appeared growing with the ordinary dry-rot, some of an unusual shape, in form like a convolvulus, with stems from a quarter to half an inch in diameter. When first exposed the whole was of a beautiful buff color, and emitted the usual smell of the dry-rot fungus.

During a part of the time occupied in the repairs of the church the weather was very rainy. The arches of the vaults having been turned before the roof was slated, the rain-water saturated the partly decayed oak beams. The flooring and joists, composed of fresh timber, were laid on the vaulting before it was dry, coming in contact at the same time with the old oak timber, which was abundantly supplied

with the seeds of decay, stimulated by moisture, the bad atmosphere of an ill-contrived burial-place, and afterward by heat from the stoves constantly in use. All these circumstances account satisfactorily for the extraordinary and rapid growth of the fungi.

The decayed state of a barn-floor attacked by rot is thus described by Mr. B. Johnson: "An oak barn-floor which had been laid twelve years began to shake upon the joists, and on examination was found to be quite rotten in various parts. The planks, two and a half inches in thickness, were nearly eaten through, except the outsides, which were glossy and without blemish. The rotten wood was partly in a state of snuff-colored, impalpable powder; other parts were black, and the rest clearly fungus. No earth was near the wood."

An indication of dry-rot in a damp pantry will be a coating of fine powder, like brick-dust, upon the shelves and earthenware, which consists of myriads of reddish spores shed by the dry-rot fungus. When these spores fall upon a wet surface, the red skin cracks at both ends, and fine filaments are sent out, which grow and ramify in all directions, and do their work of mischief with the timber of the closet.

Ventilation as a remedy for dry-rot in buildings is of doubtful service. If dry air be admitted in such a way as to absorb the moisture which sustains it, the fungus will of course be destroyed; but the trouble is that the circulating air will carry the spores along with it, and so spread the disease to unaffected parts. This is the great danger with dry-rot, while the wet-rot or ordinary decay is only communicated by actual contact. Another difficulty in ventilating for dry-rot arises from the fact that air, in passing through damp places, soon becomes humid, and loses its efficacy, or even does more harm than good. Intestinal decay is not reached by ventilation, for the air can not penetrate the spongeous exterior rottenness of timber so affected.

The temperature at which dry-rot proceeds most rapidly is 80° Fahr. At 90° it is slower, and at 100° slower still, and from 110° to 120° is generally arrested. Its progress is rapid at 50°, slow at 36°, and is arrested at 32°; but will return if the temperature is again raised to 50°. But in a constancy and equality of temperature timber will endure for ages. The wooden piles on which Venice and Amsterdam are founded remain sound because of the constancy of the conditions that surround them. Nothing is more destructive to wood than partial wetting. If it be kept always wet or always dry, and at a steady temperature, decay does not begin. It is recorded that a pile was drawn up sound from a bridge on the Danube that parted the Austrian and Turkish dominions, which had been under water fifteen hundred years. It has been remarked that the part of a ship which is constantly washed by bilge-water is never affected by dry-rot; and that the planking of a ship's bottom which is next the water remains sound for a long time, even when the inside is quite rotten.

As the decay of wood is chiefly due to the presence in it of sap, and

as dry-rot can only thrive upon decaying timber, it is apparent that the best protection against both these evils is careful seasoning. When wood dries gradually in the air by the process of natural seasoning, it should be placed in a dry yard and sheltered from sun and wind. This method may be recommended for specimens of moderate thickness; and the time needed is two years for timber used in carpentry, which in this period loses one fifth of its weight. Four years are needed for timber that is to be used in joinery, in which time it will lose one third of its weight. It is important that timber be reduced to its proper size for use before seasoning; for, however dry it may become, when it is cut smaller it will shrink and lose weight. At first the seasoning should proceed slowly, and the pores upon the surface should remain open to permit the free evaporation of internal moisture. It should be set on bearers to admit a circulation of air all around it. The sleepers at the bottom of the pile should be perfectly level and solid; for timber bent in seasoning will retain the same form when dried. The time required for drying under cover is shorter than in the open air in the proportion of five to seven. Three years are required to season ship-timber; the timbers are shaped a year before they are formed, and then left a year in a skeleton shape to complete the seasoning.

Sappy timber that must be seasoned quickly, in cases where strength is not chiefly required, should be immersed in running water as soon as felled. It should be chained down beneath the surface, as partial immersion is very destructive. Boards placed end on at the head of a mill-race for two or three weeks, and then set upright in the air, and turned daily, are said to floor better than timber that has been years in dry seasoning. The longer wood has been under water the faster it dries. The process of water-seasoning is easily explained. Sap is denser than pure water, and it is inclosed in membrane. By osmotic action pure water takes the place of the sap and so renders the wood less liable to ferment. Again, pure water evaporates more readily than water which contains certain principles in solution, and hence water-soaked timber dries more rapidly. Timber steeped in water has some of its substance dissolved thereby. Boiling and steaming are said to prevent dry-rot by getting rid of spores and coagulating albumen.

GENERIC IMAGES.

By FRANCIS GALTON, F. R. S.

IN the prescientific stage of every branch of knowledge, the prevalent notions of phenomena are mainly founded on general impressions. But when that stage is passed, and the phenomena are submitted to measurement and numbering, very many of the notions

that were derived from general impressions are discovered to be wrong, even absurdly so. I do not speak only of such matters as astrology and alchemy, but of those also with which most persons are acquainted. Think of the nonsense spoken every day about signs of coming weather, in connection, for example, with the phases of the moon, and firmly believed in by many respectable people. Think of the ideas about chance, held by those who are unacquainted with the theory of probabilities. Think of the notions entertained on heredity before the days of Darwin. Think of the ridiculous nostrums that have been prescribed for common ailments by gifted and experienced practitioners, the merits of which have been also vaunted by the invalids who tried them. It is not necessary to go into more detail in illustration of the fallacies of popular generalizations. The list of them is endless; they are to be abundantly found, as already observed, in every branch of knowledge, before it has been seized in the firm and sure grasp of processes that depend upon exact measurement and number. That popular notions are habitually incorrect may be taken for granted, and my purpose in this memoir is to explain one cause of their incorrectness.

I propose to call attention to an error in the operations of the mind, whenever it blends memories together, and to show why the brain is a faulty apparatus for elaborating general impressions. I shall argue that we have no means of correcting its necessarily fallacious results, except by picking them to pieces, and going back to the facts whence the general impressions were derived, and by dealing with those facts on true statistical principles. Thus if we hear that some medical nostrum is highly reputed, or that some particular appearance is an excellent prognostic of coming weather, our first step toward investigating the truth is not to ask whether the belief is firmly held, or of old standing, or shared by many, but to obtain a considerable number of instances and to set off the failures against the successes.

The general impressions and ideas to which I refer guide the great majority of our every-day actions. We have a general impression that the day looks rainy, and we take an umbrella. We find ourselves in a railway-carriage with a person who looks sociably inclined and agreeable, and we accost him accordingly.

In an infinity of cases like these, the opinion on which we act has not been formed by any process of reasoning; neither has it been made by considering what similar experiences we have had, and counting their results on this side and on that, but it is the effect of blending together a large number of similar incidents. These blended memories are the subject of my present memoir. I shall try to prove that blended memories are strictly analogous to blended pictures, of which I have produced many specimens by combining actual portraits together; and I shall explain the peculiarities of the images by those of the portraits; then I shall show that the brain is incompetent to blend images in their right proportions. My conclusion will be that our unreasoned impres-

sions are of necessity fertile sources of superstition and fallacy from which the child and the savage are never free, and with which all branches of knowledge are largely tainted in their prescientific stage. Lastly, that it is only by the strict methods of scientific inquiry, namely, by measurement and number, that these fallacies can be cleared away and the truth discovered.

The physiological aspect of simple and blended memories is intelligible enough in its broad outlines, and may be briefly described. Whenever any group of brain elements has been excited through an impression of one of the senses, it becomes, so to speak, tender and liable to become again excited, under the influence of other kinds of stimuli. Whatever may be the cause of any new excitation, the result of its reproduction is to create an imaginary sense-impression, similar to that by which the first excitation had been caused; and this we call memory. Blended memories must necessarily follow the excitation of many associated groups of brain elements, under the influence of a stimulus that sets them simultaneously in action.

Faint memories are particularly apt to blend together, and they often defy analysis afterward. We are shown some picture of mountain and lake, from a county we have never visited, yet it seems familiar to us; it accords with what we have seen dozens of times in Scotland or Switzerland or elsewhere, but our memories are confused and obscure, and we can not wholly disentangle the incidents to which they relate.

Memories that are extremely vivid may at the same time be very mobile, and capable of blending together. Much instruction on these matters can be derived from those who possess the power of what is called the visualizing faculty, in a high degree. The objects of their memory are conspicuous images; they can retain them for a long time before the eye of their mind, they can dismiss or change them at will, and they can, if they please, subject them to careful examination from every side. I do not know any faculty that varies so much as this in different persons. None can vary more, because its range lies between perfection and nothingness. It is sometimes absolutely deficient, for there are persons who never see mental images even in dreams, and there are others who are said to have lost the power of seeing them. I need not speak of cases where the visualizing power is feeble, as they are common. Many are like those to whom St. James alludes when he speaks of "a man beholding his natural face in a glass, who beholdeth himself and goeth his way, and straightway forgetteth what manner of man he was." It will be more to my point to show how perfect the visualizing faculty sometimes is, at the same time that the images may be moved with the utmost facility in the field of the mind's eye, which is a first step toward their blending together. Out of the many available instances I will only quote one, and will choose that one chiefly because it has recently excited some public attention. There

appeared in the "Spectator," of December 28th last, two very interesting letters concerning a peculiar form of visualizing possessed by the late Mr. Bidder, the engineer, known in early life as the "calculating boy," and this gift is possessed in a high though less degree by several of his descendants. Thus the eldest son, Mr. George Bidder, Q. C., can mentally multiply fifteen figures by fifteen, though not with the same precision and rapidity as his father. One of the two letters is from Mr. Bidder's friend, Professor Elliot, who writes thus:

> If he saw or heard a number, it seemed permanently photographed in his brain. In like manner he could study a complicated diagram without seeing it, when walking and apparently listening to a friend talking to him on some other subject. The diagram stood before him in all its lines and letters.

The second letter is from Mr. George Bidder, who writes:

> His memory was of a peculiar cast, in which figures seemed to stereotype themselves without an effort . . . . (accompanied) by an almost inconceivable rapidity of operation. I speak with some confidence on the former of these faculties, as I possess it to a considerable extent myself (though not to compare with my father). Professor Elliot says he always saw mental pictures of figures and geometrical diagrams. I always do. If I perform a sum mentally, it always proceeds in a visible form in my mind; indeed, I can conceive no other way possible of doing mental arithmetic.

Mr. Bidder continues, in a letter addressed to myself:

> If my mind is engaged solving a geometrical problem including the relations of lines, plans, etc., I *deliberately* build up in my mind a figure, plane or solid, as the case requires; but there is a limit to my power in this respect, e. g., if the problem includes the relative positions and intersections of many surfaces, it becomes a painful effort to grasp them all simultaneously.

All this shows that mental impressions of extreme vividness may at the same time have great mobility and be subject to "an almost inconceivable rapidity of operation," and that they need not be fixed in the way that hallucinations often are.

Next as regards actual blending. Mr. G. Bidder, in very kindly replying to some questions that I put, writes:

> Nothing is easier than to imagine, and to watch mentally, the rotation of anything to which such motion is natural, e. g., a wheel, a crank, etc. In many such cases I incline to think the process consists in calling up a sort of typical image formed out of innumerable bygone experiences.

This was Mr. Bidder's own view, quite independent of any suggestions from myself, and is therefore all the more valuable.

The strongest proof that those who have vivid memories of special objects are also capable of blending them is found in the works of such men as Macaulay. I am assured on excellent authority that his visual memory of book, page, and line was of the clearest possible char-

acter; it was described to me as having been "spectral" in its perfect definition. Yet no one better than Macaulay had the power of vivid generalization, that is, of creating a single clear image out of a multitude of allied facts. Many poets and painters have had the visualizing faculty in an extraordinary degree, while it is in the brains of poets and painters generally that we find the artistic power to reside of producing pictures that are not copies of any individual, but represent the characteristics of large classes. Painters and poets create blended portraits in profusion, and we, who are not gifted as they are, can nevertheless understand and appreciate their works. In other words, their blended images are well-defined representations of what we ourselves had already conceived in a dim and confused way.

There seems, then, to be no doubt, from whatever side we may approach the subject of memory—whether from its material or its mental aspect, and, in the latter case, whether the visualizing faculty be faint or vivid—that different special memories admit with facility of being blended into a common image. From blended memories to general impressions and ideas is a step on which we need not linger, the latter being derived from the former. They are faint traces of them, and they inherit all their errors.

I conclude, then, that the formation of blended images is an habitual operation of the mind, whence those general impressions have arisen by which the great majority of our daily actions are guided.

I will now proceed to speak of blended portraits, in order to illustrate the formation of blended memories and the effect of the resultant images; or let me henceforth describe them as generic portraits and generic mental images. The word generic presupposes a genus. The objects to be portrayed must all have many points of likeness in common, and it is of especial importance that characteristics of a medium quality should be much more common among them than those that deviate widely. No statistician dreams of grouping heterogeneous facts in the same table; no more do I propose to group heterogeneous forms in the same picture. Statistical averages, and the like, are nonsensical productions unless they apply to objects that cluster toward a common center; and composite pictures are equally monstrous or meaningless unless they are compounded of objects that have a common similarity to a central ideal type.

It might be thought that blended portraits would form mere smudges, and so they would if only a few specimens of extremely different casts of features were combined, but in all groups that may be called generic the common points of resemblance are so numerous, and medium characteristics are so much the more frequent, that they predominate in the result. All that is common to the group remains; all that is individual disappears.

Generic portraits are made by a method which I described for the

first time last year, under the title of composite portraiture. I showed that it was possible in many ways to combine two or more portraits into a single one, if they are of the same size and taken in the same attitude. I have produced the combination by various optical means, such as the convergence of images from different magic lanterns upon the same screen, and by a small apparatus which is, in fact, six cameras in combination, in which six different images may be simultaneously viewed, and afterward thrown upon the same photographic plate. In addition to these is the plan I originally employed, of throwing carefully adjusted images of different portraits in succession upon the same portion of the same sensitized photographic plate. It is by the latter process that blended memories are illustrated. In all these methods the general result is substantially the same, subject only to such discrepancy as will always exist between a photograph and the image from which it is made. A composite portrait is in all cases produced, in which the whole of the components coexist. It is surprising with what excellent effect we can combine the features of persons who are not too dissimilar in their general appearance. We obtain from them a composite portrait that is identical with no one of the components, but which comprises all, each having its own fractional share in the total effect. I have made several composites from medals of historical personages; such as from different coins bearing the effigy of Alexander the Great, none of which are closely alike. Thus I have brought out the common features of all of them and produced what is presumably a nearer approach to the ancient ideal type than has ever previously existed. I am much indebted to the kindness of Mr. R. Stuart Poole, the learned curator of the magnificent collection of medals and gems in the British Museum, for having selected the best and most suitable specimens, and having procured plaster casts of them for me, whence my photographs were made. The portraits on coins are very convenient for composites, as they are pure profiles. I have also various criminal types, composed from the photographs of men convicted of heinous crimes. They are instructive as showing the type of face that is apt to accompany criminal tendencies, *before* (if I may be allowed the expression) the features have become brutalized by crime. The brands of Cain are varied; therefore the special expressions of different criminals do not reënforce one another in the composite, but disappear. What remain are types of faces on which some one of the many brands of Cain is frequently destined to be set. I am particularly struck by three of these types that were each deduced from six or seven components; two of the groups are of men convicted of manslaughter and crimes of violence, the other of habitual thieves. These three composites are as alike as brothers; the compound composite gives a low class of face, but not one, I think, that most persons would associate with especial villainy. I have also two other composites very like these three, and I find that,

whenever I put any three of the five together, I arrive at very nearly the same typical face.*

The process is one of pictorial statistics, suitable to give us generic pictures of man, such as Quetelet obtained in outline by the ordinary numerical methods of statistics, as described in his work on "Anthropométrie." He procured the measurements of the limbs of a large number of person of both sexes and of various ages, and of the distances between such points on the surface of the body as are sufficiently defined to measure from. From these numerical data he calculated and laid down upon paper the average positions of those points, and therefrom constructed sketches of the typical man at various periods of his growth, like Flaxman's drawings or Retsch's outlines. By the process of composites we obtain a picture and not a mere outline. It is blurred, something like a damp sketch, and the breadth of the blur measures the variability of individuals from the central typical form.

It may be objected that the contribution from each portrait, when there is a multitude of them, is so small that, in the great majority of cases, it might perhaps leave no trace at all in the generic portrait, or, at all events, on the photograph ; consequently, that the result may not be what it professes, but is, perhaps, due to a comparatively small portion of the components, in which the lights and shades happen to be sufficiently marked to create a decided impression. I therefore tried a simple experiment, which leaves no doubt that this objection is unfounded under even very exceptional circumstances, so far as the photographs are concerned, and, therefore, *a fortiori*, as regards composite results by purely optical means. I contrived a small apparatus to be held in one hand. It had a receptacle behind for sensitized paper, in front of which was a hole closed by a shutter, that sprang back when I pressed my finger on a catch, and closed at the moment that I released the pressure. In the other hand I held a chronograph, in which the hand that marked quarter-seconds began to travel the instant I pressed a catch, and stopped when I released it. I worked these two instruments simultaneously, holding one in each hand. The chronograph readings gave me the sum of the successive short periods of exposure of the sensitized paper, and I could watch the length of each of them. Thus provided, I made several experiments, and can testify to the identity of the tint made by one thousand short exposures with that made by a single exposure of the same length of time as all the thousand put together. What differences there were, lay well within the limits of error in experimenting.

Composite portraits are, therefore, much more than averages, because they include the features of every individual of whom they are composed. They are the pictorial equivalents of those elaborate sta-

* I exhibited many photographic composites at the Royal Institution on the 25th of April. Some were transparencies thrown upon a screen, others were made before the audience by converging magic lanterns.

tistical tables out of which averages are deduced. There can not be a more perfect example than they afford, of what the metaphysicians mean by generalizations, when the objects generalized are objects of vision, and when they belong to the same typical group, one important characteristic of which is that medium characteristics should be far more frequent than divergent ones. It is strange to notice how commonly this conception has been overlooked by metaphysicians, and how positive are their statements that generalizations are impossible, and that the very idea of them is absurd. I will quote the lucid writing of Sir W. Hamilton to this effect, where he epitomizes the opinions of other leading metaphysicians. I do so the more readily because I fully concede that there is perfect truth in what he says, when the objects to be generalized are not what a cautious statistician would understand by the word generic.

Sir W. Hamilton says :*

> Take, for example, the term *man*. Here we can call up no notion, no idea, corresponding to the universality of the class, or term. This is manifestly impossible. For as *man* involves contradictory attributes and as contradictions can not exist in one representation, an idea or notion adequate to *man* can not be realized in thought. The class *man* includes individuals, male and female, white and black and copper-colored, tall and short, fat and thin, straight and crooked, whole and mutilated, etc., and the notion of the class must therefore at once represent all and none of these. It is therefore evident, though the absurdity was maintained by Locke, that we can not accomplish this; and, this being impossible, we can not represent to ourselves the class *man* by any equivalent notion, or idea. All that we can do is to call up some individual image and consider it as representing, though inadequately representing, the generality. This we can easily do, for as we can call into imagination any individual, so we can make that individual image stand for any or for every other which it resembles, in those essential points which constitute the identity of the class. This opinion, which, after Hobbes, has been in this country maintained among others by Berkeley, Hume, Adam Smith, Campbell, and Stewart, appears to me not only true but self-evident.

If Sir W. Hamilton could have seen and examined these composite portraits, and had borne in mind the well-known elements of statistical science, he would certainly have written very differently. No doubt, if what we are supposed to mean by the word *man* is to include women and children and is to relate only to their external features and measurements, then the subject is not suitable for a generic picture, other than of a very blurred kind, such as a child might daub with a paint-brush. If, however, we take any one of the principal races of man and confine our portraiture to adult males, or adult females, or to children whose ages lie between moderate limits, we ought to produce a good generic representation.

It will, I trust, be quite understood that, although for the sake of

* "Lectures," ii., 297.

brevity I chiefly confine my remarks to visual representations, they are intended to apply equally to all the senses.

A generic image appears to be nothing more than a generic portrait stamped on the brain by the successive impressions made by its component images. Professor Huxley, from whom I have borrowed the apt phrase, has expressed himself to a similar effect in his recent "Life of Hume," page 95. I am rejoiced to find that from a strictly physiological side this explanation is considered to be the true one, by so high an authority, and that he has, quite independently of myself, adopted a view which I also entertained, and had hinted at in my first description of composite portraiture, though there was not occasion at that time to write more explicitly about it.

When I am adjusting portraits to make a composite, and at the moment when the adjustment is being effected, I always experience a quick sense of satisfaction curiously analogous to that which is felt on the first recognition of a doubtful likeness of any kind. I have the same disagreeable feeling of the existence of a puzzle which I can not make out, accompanied by the conviction that the puzzle is on the point of being solved. In the next instant coalescence takes place between what is seen and what was recollected. I am as sure as it is possible to be on such grounds as these, that the analogy between catching the coincidence of two similar portraits when optically superposed and that of the coincidence of a visible object with a past impression or with a preëxistent general idea is true and not metaphorical only.

It is very instructive to note the first appearance of a generic image, and to watch the way in which the mind carves images out of the medley of its available material. It can not grasp an image of any complexity unless the elements of which it consists form a congruous composition, that is to say, one whose parts are connected by such easy lines of association that the mind runs rapidly over the whole of it, and takes it all in by what seems to be a single glance. Generic images begin, at least according to my own experience, by being exceedingly imperfect and vague because they are very comprehensive. Then limitations commence, each of which is the cause of a more distinct picture being formed, and so the mind runs first through genera, then through species, continually seeking more congruity and clearer definition, but at each step with a loss of comprehensiveness. If allowed to do so, it descends to individuals. Let us, as an example, call up a generic image of a clergyman preaching. I first see a pulpit of somewhat undefined height, with a vague figure in it. This figure becomes white, in a surplice; a competing figure in a black ground temporarily yielding place. Then I see various accessories suitable to the surplice, such as Gothic architecture, ritualistic decorations, and the like. After this the interiors of particular churches begin to present themselves, but, as I wish to confine my

thoughts to generalities, I refuse to dwell upon single cases. While waiting for some new general idea to suggest itself, I have the consciousness of there being many competing images struggling to appear, which do not belong to the same genus, and therefore restrain instead of reënforcing one another. At length the black-robed figure suddenly reappears; on viewing which, the accessories assume an appropriate character, and the mind wanders among a variety of these, as it had previously done among the others. In the course of the degradation of highly generalized pictures to individual ones, many generic representations are sure to appear which are good so far as they go, but are not complete pictures. Whenever the mind has halted in a vain effort to make the image more comprehensive without injuring its congruity, the dead-lock is relieved by the sudden obliteration of a large part of it, leaving a vacancy which is filled by some one of the competing associations overcoming the others, and presenting itself within the narrow field of view of our full consciousness and attention.

Other conditions being the same, it is reasonable to suppose that the idea that has been most frequently dwelt upon will have left the deepest impression on the brain, and will have precedence. Thus, in making a drawing of a pendulum in the act of swinging, we should always represent it at one or other side of its excursion, when it delays, stops for an instant, and returns. We see it longer in either of those extreme positions than in any of the intermediate ones. Similarly, we draw a man walking, or otherwise in motion, in the attitude where there is a momentary change of direction, and consequently more or less of rest at or about that position. It is different when the movement is continuous; the wheel of a moving carriage is drawn in a blur, with, however, numerous radial streaks, showing, if I mistake not, that attentive observation is never continuous, but acts in rapid pulses, so that the revolving wheel is seen in many momentary positions. I have endeavored, in this way, to measure the intervals between the successive throbs of close attention. If a wheel revolves rapidly, it is impossible to analyze its motion, and its spokes form an apparently equable shade.

In my memoir, read about a year ago before the Anthropological Institute, on composite portraits, I used a phrase, which I wrote with a little misgiving, which I have since quoted, and which I wish now to amend. I desired briefly to convey the idea that composite portraits were in a true sense generalizations and analogous to the images stamped on the brain, as already described, and I used these words: "A composite portrait represents the picture that could rise before the mind's eye of an individual who had the gift of pictorial imagination in an exalted degree."

The question we have now to answer is this:

If a person gifted with the visualizing power in perfection should pose his eye in the place of the object-glass of the camera, would the

generic image in his brain be identical with the photographic composite? (I am assuming, for argument's sake, that the photograph gives a true rendering of any optical image, which, in strictness, it does not.) Suppose a succession of many different pictures are to be displayed, each for the same brief period, and if a single other picture is displayed fifty times in succession, or for fifty times as long, would its share in the generic image be fifty times as large as that of any of the others, or, if not, what would its share be?

The reply is, that both in the photographic composite and in the processes of numerical statistics, its effect would be exactly fifty times as great, but in mental imagery this would certainly not be the case, and therein lies a fertile source of error in our general impressions. I have made some experiments on the subject, which are not as yet sufficiently advanced to be worth recording, but I may say that at present I see nothing in the results imcompatible with the very reasonable supposition that the relation between the varying periods of exposure and the strength of the corresponding mental impression follows the law of Weber. This law is founded in the fact that, the more highly our senses are stimulated, the more is their discriminative power blunted. Thus a double number of candles does not double the apparent illumination; it only increases it by a certain amount, which is always the same, whether the light of a single candle be added to that of another single candle, or the light of a thousand candles be added to that of another thousand candles. The law is true of all the senses. The difference of noise made by dropping one shilling or two shillings on a table is not always distinguished by the ear, neither is that of discharging one or two thirty-eight-ton guns from the turret of the same iron-clad ship, as was shown in evidence concerning the recent frightful accident on board the Thunderer. That is to say, the same increment of noise may be produced by the fall of a shilling on a table, in the one case, as by a thirty-eight-ton gun in the other.

Let me take the present opportunity of saying that one effect of Weber's law is that a true composite never appears true, and is never what our uncorrected senses teach us to expect. If we mix a very dark gray with a very light gray, we might on first thoughts expect that their mixture would appear to be a medium gray, but Weber's law tells us that the eye judges differently, and we find, in trying the experiment, that the mixture is brighter than we had expected.* Of

* Weber's law may be well illustrated by placing in a row, say, five cards, painted quite black, each the size of half a sheet of note-paper. Then taking a whole sheet of white note-paper, tear it in half and lay one half on card 5 so as to cover it entirely. Tear the remaining half exactly across its middle and lay one half upon card 4; again tear the remainder in half and lay one half on card 3. Proceed similarly up to card 1; the fragment that remains is not wanted. Cut these papers into shreds (excepting No. 5, which can be left as it is), and distribute the shreds as evenly as possible over their respective cards. Then 1 will have one portion of white, 2 will have two portions, 3 will have four portions, 4 will have eight, and 5, which is wholly covered with white, will have

course, we could learn by much practice to correct the judgment of our senses, but it is only in rare and special cases that we have the necessary practice. I have often noticed my own ludicrous failures in estimating the relative depths of two parts of the same pool by the relative obscurity of the bottom. Maps of ocean-depths are never made on what may be called natural scales, but always on symbolic ones, in which consecutive increases of tint, as judged by the eye, correspond to successive increases of depth. According to Weber's law (which I content myself here with expressing in its original and approximative form), if it requires a tenfold period of exposure to make a doubly deep impression on the mind, it would require a hundred-fold period to make a trebly deep one, a thousand-fold period to make it quadruply deep, and so on. The one series follows an arithmetical, the other a geometrical progression.

Whatever the true law may be that connects the strength of the impression with the time that the object is before our eyes, or with the frequency with which it is seen, its form is certainly not very dissimilar to that of the law of Weber. Otherwise it would not accord with the fact that sights on which we have not lingered, often leave abiding impressions, while the pictures that hang on our walls, before our eyes, every day of our life, are not always remembered with vivid distinctness. The effect of the law, whatever its precise form may be, is to prevent generic images from having the same definition and simplicity as the corresponding photographs. The most extreme elements will always leave their traces very visibly because the medium elements are not present in sufficient number to overpower them. These images can not be otherwise than blurred and surrounded by monstrous and faint imagery. The attention is unable to deal with such pictures, because when it is engaged on one part of them the remainder slips out of memory. All parts of an image must be congruous and well defined before the attention can sweep so swiftly over the entire field of view as practically to bring it all at once into sight. If an image is incongruous and vague, the mind follows the course already described when the illustration was used of a clergyman in a pulpit.

The conclusions to be drawn from what I have said are that composite portraits are perfectly trustworthy when made by optical means and with proper precautions, and that photographic composites are as correct representations of these as photographs ever are of the pictures from which they are taken. Composite portraits are therefore to be considered as pictorial statistics. Also it is conceivable that general

sixteen. The effect of the scattered white on the cards is to produce various grays which the eye will judge to be separated by equal intervals of tint. Card 4, which contains eight portions, has the medium amount of white (eight and a half is the precise medium), but the eye reckons differently; it places the medium tint at card 3, which contains only four portions of white.

mental images should sometimes closely resemble these portraits except in one important respect; namely, that the effect produced by the huge bulk of ordinary facts is never in proportion to their numbers. Consequently, we find that undue consideration is inevitably given in generic images to all exceptional cases. When the exceptions in excess are balanced by those in deficiency, the value of the average will not be affected, and there is always a tendency toward that result. The fault that remains wholly uncorrected is, that the great prevalence of mediocre instances is overlooked, and the number and importance of the deviations are largely over-estimated. The tendency of the mind of the child and of the savage, and in all branches of knowledge in their prescientific stage, is necessarily toward the marvelous and the miraculous.

The generic images that might arise in a mind superhumanly logical and active would be subject to no other error than this, but in the human mind it is not so. Some of the images in every presumed generic group are sure to be aliens to the genus and to have become associated to the rest by superficial and fallacious resemblances, such as common minds are especially attentive to. Again, the number of pictures that are blended together is sure to fall far short of the whole store that would be available if the memory were immeasurably stronger than it is, and more ready in its action. Knowing also as I do, from considerable experience of composites, what monstrous and abortive productions may result from ill-sorted combinations of portraits, and how much care in selection and nicety of adjustment is required to produce the truest possible generic image, I cease to wonder at the numerous shortcomings in our generalizations and at their absurd and frequent fallacies. The human mind is a most imperfect apparatus for the elaboration of true general ideas. Compared with the mind of brutes, its powers are marvelous; but for all that they fall vastly short of perfection. The criterion of a perfect mind would be the power of always creating vivid images of a truly generic kind, deduced from the whole range of its past experiences.

General impressions are the faint traces left by generic images, and have all their defects, as well as others, due to their own want of definition. They are never to be trusted. Unfortunately, when general impressions are of long standing they become fixed rules of life, and assume a prescriptive right not to be questioned. Consequently, those who are not accustomed to original inquiry entertain a hatred and horror of statistics. They can not endure the notion of submitting their sacred general impressions to cold-blooded verification. But it is the triumph of scientific men to rise superior to such superstitions, to devise tests by which the value of beliefs may be ascertained, and to feel sufficiently masters of themselves to discard contemptuously whatever may be found untrue.—*Nineteenth Century.*

MONARCHY AND ITS DRAWBACKS.

VERY nearly a century and a half ago David Hume observed, with an air of surprise, that no form of government had proved so susceptible of improvement as monarchical government. "It may now," he writes, "be affirmed of civilized monarchies what was formerly said of republics alone, that they are a government of laws, not of men." There was only one constitutional monarchy in Hume's day—that of Great Britain, which he did not particularly love; and the only existing republics were strict aristocracies, such as the Venetian Republic and the Swiss Cantons. Hume was avowedly taking into account, not only such countries as France and Spain, but the little despotisms of Italy and Germany. "There are, perhaps, and have been for two centuries, near two hundred absolute princes, great and small, in Europe; and, allowing twenty years to each reign, we may suppose that there have been on the whole two thousand monarchs or tyrants, as the Greeks would have called them; yet of these there has not been one, not even Philip II. of Spain, so bad as Tiberius, Caligula, Nero, Domitian, who were four in twelve among the Roman Emperors." Since then the world has seen two great examples of that republican government which Hume assumes without question to be abstractedly the best—the Republic of the United States and the first French Republic; and assuredly the result has been considerable disenchantment. Nobody would nowadays deny that monarchy has proved capable of yet greater improvement than even Hume thought possible; and only a small minority of men, and those certainly not consisting of deep political thinkers, is persuaded that a country gains very much by exchanging an hereditary for an elective Chief Magistrate.

But of course a monarchy implies a dynasty; and dynasties are always raising a number of questions so perplexing that they are a considerable drawback on the value of monarchical government. In the first place, there is no subject on which men as a fact have fought and still fight so much. This country was for a hundred years at war with France on a question of the kind; and the war which it has just successfully concluded with Afghanistan sprang in great part from the same cause, since it was a doubt whether the Prince could nominate his own successor which primarily threw Shere Ali into the arms of the Russians. These questions of succession mix themselves up with the entire politics of countries in which there is no open strife about them. The position of the British monarchy and the view taken of it are strongly influenced by the double fact that our line of kings came in with a defective title, but that these defects have been practically removed by the course of circumstances and by time. The relation, again, of the Count de Chambord to his far-away cousins of

the Orleans branch deeply affects all French politics; and the untimely death of the Prince Imperial is a still more important factor in them.

Mr. Huxley, criticising these speculations of Hume in his recent volume, expresses the opinion that monarchies in our day are less likely to fall into discredit through inherent drawbacks or through the competition of republics than through their "tendency to become slightly absurd." The maintenance of kingship is undoubtedly dependent in great part on the majesty of kings; but this majesty is preserved with increasing difficulty. The purple robe has not only become frayed, but the wearer is sometimes under a strong temptation to exchange it for a dressing-gown. It is hard to say what is the safest general behavior for a royal personage. If monarchy retires into seclusion, people nowadays ask what is the good of it, and grumble at its costliness. If it associates itself with the tastes which are conventionally regarded as most respectable, by cultivating art, science, or letters, it incurs the repugnance of the multitude to whom these tastes are a symbol of pedantry or effeminacy. If, on the other hand, it simply enjoys itself, it becomes the prey of that overdone morality which is always affected by the dealers in malignant gossip. No doubt the Prince who died the other day in Paris was a good example of the class of idiosyncrasy which endangers monarchy. There was nothing remarkable about him save his exceptional rank and the historical dignity of his name. The type is perfectly well known—that of the foreign prodigal who wastes his substance in the city in which pleasure has become a business; and not simply a business, but a business conducted on the strictest commercial principles. But, if the heirs-apparent of thrones were often seen in the circles frequented by the last Prince of Orange, there would be a rapid decline of that kingly majesty which when it wholly disappears leaves (as Mr. Huxley justly says) little but absurdity behind it. The question between monarchies and republics would then be reduced to a simple question of their respective convenience; and, in countries governed as ours is, the question of convenience is very likely to end in turning on a mere calculation of cheapness or cost.

It is plain from Hume's language that the commonplaces of his day were all in favor of republics. There is in fact hardly a single writer of the time who does not praise them, though they all assume that a superhuman amount of diffused public virtue is necessary for their conduct. As we before said, the only known republics were petty or anomalous oligarchies; and the eulogies in fashion were in reality taken from classical panegyrics on Greek and Roman republics, profoundly misunderstood. There are countries which have severely suffered from this enthusiasm founded on ignorance. France owes to it the most fearful as well as the most absurd of her experiences during the first Revolution, and she is hardly free even now from some of

its evil effects. The over-estimate of the republican form of government based on classical commonplace has, among other things, prevented our knowing what may be said for or against its establishment in the older parts of the world. French republics have up to this time chiefly failed because too much was expected from them. If we look to facts for our guidance, we have few to rely upon except those furnished by the comparatively short history of the group of States making up the American Union. Now, the spectacle of the United States suggests not that a republican government is what it was deemed to be by most Englishmen in 1793, but that it is a government hardly worth the trouble of adopting in 1879. It is neither a Utopia of bliss nor a den of assassins and thieves, but simply a set of institutions like another, with advantages and drawbacks keeping the scales nearly evenly poised. The attractions which it had for thinkers of the once famous Utilitarian school plainly arose from miscalculation. They argued that the interests of a community were the interests of the greatest number of men in it; and that therefore every government which rested on the votes of this greatest number, and did not disturb their verdict by collateral influences, would be sure by the nature of the case to promote the true interest of the nation. It has turned out in practice that few men out of a community will give attention to the interests of the community, and that fewer still can see or understand them. Thus the experience of republican government in America has ended in a great deal of disillusion. It is not that men may not be happy and prosperous under republics, but that they are not happier or more prosperous than under many of the forms of monarchy. A people living under republican institutions is plainly not wiser, nor more virtuous, nor more peaceable for its government; nor is this government cheaper or less clumsy in its practical working than others. A certain amount of social ease and independence is attributed to American society by those who have observed it; but it does not appear to have any greater respect or regard for cultivation than the ordinary society of older countries. On the whole, if monarchy and republicanism come into competition, and the victory be decided by the results of experience, there is no particular reason why republicanism should prevail. The probability is, however, that, if the throne were to give place to the presidential chair in a country like ours, the substitution would not be caused by any deliberate preference for republican institutions, but by the aggregation of some or all of those drawbacks on monarchy which we have noticed until they have become intolerable.—*Pall Mall Budget.*

GEOGRAPHICAL EVOLUTION.*

By Professor ARCHIBALD GEIKIE, F. R. S.

I.

IN the quaint preface to his "Navigations and Voyages of the English Nation," Hakluyt calls geography and chronology "the sunne and moone, the right eye and the left of all history." The position thus claimed for geography three hundred years ago by the great English chronicler was not accorded by his successors, and has hardly been admitted even now. The functions of the geographer and the traveler, popularly assumed to be identical, have been supposed to consist in descriptions of foreign countries, their climate, productions, and inhabitants, bristling on the one hand with dry statistics, and relieved on the other by as copious an introduction as may be of stirring adventure and personal anecdote. There has, indeed, been much to justify this popular assumption. It was not until the key-note of its future progress was struck by Karl Ritter, within the present century, that geography advanced beyond the domain of travelers' tales and desultory observation into that of orderly, methodical, scientific progress. This branch of inquiry, however, is now no longer the pursuit of mere numerical statistics, nor the chronicle of marvelous and often questionable adventures by flood and fell. It seeks to present a luminous picture of the earth's surface, its various forms of configuration, its continents, islands, and oceans, its mountains, valleys, and plains, its rivers and lakes, its climates, plants, and animals. It thus endeavors to produce a picture which shall not be one of mere topographical detail. It ever looks for a connection between scattered facts, tries to ascertain the relations which subsist between the different parts of the globe, their reactions on each other and the function of each in the general economy of the whole. Modern geography studies the distribution of vegetable and animal life over the earth's surface, with the action and reaction between it and the surrounding inorganic world. It traces how man, alike unconsciously and knowingly, has changed the face of nature, and how, on the other hand, the conditions of his geographical environment have molded his own progress.

With these broad aims, geography comes frankly for assistance to many different branches of science. It does not, however, claim in any measure to occupy their domain. It brings to the consideration of their problems a central human interest, in which these sciences are sometimes apt to be deficient; for it demands first of all to know how the problems to be solved bear upon the position and history of man and of this marvelously ordered world wherein he finds himself undisputed lord. Geography freely borrows from meteorology, physics, chemistry,

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geology, zoölogy, and botany; but the debt is not all on one side. Save for the impetus derived from geographical research, many of these sciences would not be in their present advanced condition. They gain in vast augmentation of facts, and may cheerfully lend their aid in correlating these for geographical requirements.

In no respect does modern geography stand out more prominently than in the greater precision and fullness of its work. It has fitted out exploratory expeditions, and in so doing has been careful to see them provided with the instruments and apparatus necessary to enable them to contribute accurate and definite results. It has guided and fostered research, and has been eager to show a generous appreciation of the labors of those by whom our knowledge of the earth has been extended. Human courage and endurance are not less enthusiastically applauded than they once were; but they must be united to no common powers of observation before they will now raise a traveler to the highest rank. When we read a volume of recent travel, while warmly appreciating the spirit of adventure, fertility of resource, presence of mind, and other moral qualities of its author, we instinctively ask ourselves, as we close its pages, What may be the sum of its additions to our knowledge of the earth? From the geographical point of view—and it is to this point alone that these remarks apply—we must rank an explorer according to his success in widening our knowledge and enlarging our views regarding the aspects of nature.

The demands of modern geography are thus becoming every year more exacting. It requires more training in its explorers abroad, more knowledge on the part of its readers at home. The days are drawing to a close when one can gain undying geographical renown by struggling against man and beast, fever and hunger and drought, across some savage and previously unknown region, even though little can be shown as the outcome of the journey. All honor to the pioneers by whom this first exploratory work has been so nobly done! They will be succeeded by a race that will find its laurels more difficult to win—a race from which more will be expected and which will need to make up in the variety, amount, and value of its detail, what it lacks in the freshness of first glimpses into new lands.

With no other science has geography become more intimately connected than with geology, and the connection is assuredly destined to become yet deeper and closer. These two branches of human knowledge are, to use Hakluyt's phrase, "the sunne and moone, the right eye and the left," of all fruitful inquiry into the character and history of the earth's surface. As it is impossible to understand the genius and temperament of a people, its laws and institutions, its manners and customs, its buildings, and its industries, unless we trace back the history of that people, and mark the rise and effect of each varied influence by which its progress has been molded in past generations; so it is clear that our knowledge of the aspect of a continent, its mountains

and valleys, rivers and plains, and all its surface features, can not be other than singularly feeble and imperfect, unless we realize what has been the origin of these features. The land has had a history, not less than the human races that inhabit it.

One can hardly consider attentively the future progress of geography without being convinced that, in the wide development yet in store for this branch of human inquiry, one of its main lines of advance must be in the direction of what may be termed geographical evolution. The geographer will no longer be content to take continents and islands, mountain-chains and river valleys, table-lands and plains, as initial or aboriginal outlines of the earth's surface. He will insist on knowing what the geologist can tell him regarding the growth of these outlines. He will try to trace out the gradual evolution of a continent, and may even construct maps to show its successive stages of development. At the same time he will seek for information regarding the history of the plants and animals of the region, and may find much to reward his inquiry as to the early migrations of the fauna and flora, including those even of man himself. Thus his pictures of the living world of to-day, as they become more detailed and accurate, will include more and more distinctly a background of bygone geographical conditions, out of which, by continuous sequence, the present conditions will be shown to have arisen.

I propose this evening to sketch in mere outline the aspects of one side of this evolutional geography. I wish to examine, in the first place, the evidence whereby we establish the fundamental fact that the present surface of any country or continent is not that which it has always worn, and the data by which we may trace backward the origin of the land; and, in the second place, to consider, by way of illustration, some of the more salient features in the gradual growth of the framework of Europe.

The first of these two divisions of the subject deals with general principles, and may be conveniently grouped into two parts: 1. The Materials of the Land. 2. The Building of the Land.

THE MATERIALS OF THE LAND.—Without attempting to enter into detailed treatment of this branch of the subject, we may, for the immediate purpose in view, content ourselves with the broad, useful classification of the materials of the land into two great series, (*a*) Fragmental and (*b*) Crystalline.

(*a.*) *Fragmental.*—A very cursory examination of rocks in almost any part of the world suffices to show that by far the larger portion of them consists of compacted fragmentary materials. Shales, sandstones, and conglomerates in infinite variety of texture and color, are piled above each other to form the foundation of plains and the structure of mountains. Each of these rocks is composed of distinct particles, worn by air, rain, frost, springs, rivers, glaciers, or the sea, from previously existing rocks. They are thus derivative formations, and their source,

as well as their mode of origin, can be determined. Their component grains are for the most part rounded, and bear evidence of having been rolled about in water. Thus we easily and rapidly reach a first and fundamental conclusion—that the substance of the main part of the solid land has been originally laid down and assorted under water.

The mere extent of the area covered by these water-formed rocks would of itself suggest that they must have been deposited in the sea. We can not imagine rivers or lakes of magnitude sufficient to have spread over the sites of the present continents. The waters of the ocean, however, may easily be conceived to have rolled at different times over all that is now dry land. But the fragmental rocks contain within themselves proof that they were mainly of marine and not of lacustrine or fluviatile origin. They have preserved in abundance the remains of foraminifera, corals, crinoids, mollusks, annelides, crustaceans, fishes, and other organisms of undoubtedly marine habitat, which must have lived and died in the places where their traces remain still visible.

But not only do these organisms occur scattered through sedimentary rocks; they actually themselves form thick masses of mineral matter. The Carboniferous or Mountain limestone of Central England and Ireland, for example, reaches a thickness of from two thousand to three thousand feet, and covers thousands of square miles of surface. Yet it is almost entirely composed of congregated stems and joints and plates of crinoids, with foraminifera, corals, bryozoans, brachiopods, lamellibranchs, gasteropods, fish-teeth, and other unequivocally marine organisms. It must have been for ages the bottom of a clear sea, over which generation after generation lived and died, until their accumulated remains had gathered into a compact sheet of rock. From the internal evidence of the stratified formations we thus confidently announce a second conclusion—that a great portion of the solid land consists of materials which have been laid down on the floor of the sea.

From these familiar and obvious conclusions we may proceed further to inquire under what conditions these marine formations, so widely spread over the land, were formed. According to a popular belief, shared in perhaps by not a few geologists, land and sea have been continually changing places. It is supposed that while, on the one hand, there is no part of a continent over which sea-waves may not have rolled, so, on the other, there is no lonely abyss of the ocean where a wide continent may not have bloomed. That this notion rests upon a mistaken interpretation of the facts may be shown from an examination—(1) of the rocks of the land, and (2) of the bottom of the ocean.

Among the thickest masses of sedimentary rock—those of the ancient palæozoic systems—no features recur more continually than the alternations of different sediments, and the recurrence of surfaces covered with well-preserved ripple-marks, trails and burrows of annelides, polygonal and irregular desiccation-marks, like the cracks at the bot-

tom of a sun-dried, muddy pool. These phenomena unequivocally point to shallow and even littoral waters. They occur from bottom to top of formations which reach a thickness of several thousand feet. They can be interpreted only in one way, viz., that the formations in question began to be laid down in shallow water; that during their formation the area of deposit gradually subsided for thousands of feet; yet that the rate of accumulation of sediment kept pace on the whole with this depression; and hence, that the original shallow-water character of the deposits remained, even after the original sea-bottom had been buried under a vast mass of sedimentary matter. Now, if this explanation be true, even for the enormously thick and comparatively uniform formations of older geological periods, the relatively thin and much more varied formations of later date can offer no difficulty. In short, the more attentively the stratified rocks of the crust of the earth are studied, the more striking becomes the absence of any formations among them which can legitimately be considered those of a deep sea. They have all been deposited in comparatively shallow water.

The same conclusion may be arrived at from a consideration of the circumstances under which the deposition must have taken place. It is evident that the sedimentary rocks of all ages have been derived from the degradation of land. The gravel, sand, and mud, of which they consist, existed previously as part of mountains, hills, or plains. These materials carried down to the sea would arrange themselves there as they do still, the coarser portions nearest the shore, the finer silt and mud farthest from it. From the earliest geological times the great area of deposit has been, as it still is, the marginal belt of sea-floor skirting the land. It is there that nature has always strewed "the dust of continents to be." The decay of old rocks has been unceasingly in progress on the land, and the building up of new rocks has been as unintermittently going on underneath the adjoining sea. The two phenomena are the complementary sides of one process, which belongs to the terrestrial and shallow oceanic parts of the earth's surface and not to the wide and deep ocean-basins.

Recent explorations of the bottom of the deep sea all over the world have brought additional light to this question. No part of the results obtained by the Challenger Expedition has a profounder interest for geologists and geographers than the proof which they furnish that the floor of the ocean-basins has no real analogy among the sedimentary formations which form most of the framework of the land. We now know by actual dredging and inspection that the ordinary sediment washed off the land sinks to the sea-bottom before it reaches the deeper abysses, and that, as a rule, only the finer particles are carried more than a few score of miles from the shore. Instead of such sandy and pebbly material as we find so largely among the sedimentary rocks of the land, wide tracts of the sea-bottom at great depths are covered with various kinds of organic ooze, composed sometimes of minute calcareous forami-

nifera, sometimes of siliceous radiolaria or diatoms. Over other areas vast sheets of clay extend, derived apparently from the decomposition of volcanic detritus, of which large quantities are floated away from volcanic islands, and much of which may be produced by submarine volcanoes. On the tracts farthest removed from any land the sediment seems to settle scarcely so rapidly as the dust that gathers over the floor of a deserted hall. Mr. Murray, of the Challenger staff, has described how from these remote depths large numbers of sharks' teeth and ear-bones of whales were dredged up. We can not suppose the number of sharks and whales to be much greater in these regions than in others where their relics were found much less plentifully. The explanation of the abundance of their remains was supplied by their varied condition of decay and preservation. Some were comparatively fresh, others had greatly decayed, and were incrusted with or even deeply buried in a deposit of earthy manganese. Yet the same cast of the dredge brought up these different stages of decay from the same surface of the sea-floor. While generation after generation of sea creatures drops its bones to the bottom, now here, now there, so exceedingly feeble is the rate of deposit of sediment, that they lie uncovered, mayhap, for centuries, so that the remains which sink to-day may lie side by side with the moldered and incrusted bones that found their way to the bottom hundreds of years ago.

Another striking indication of the very slow rate at which sedimentation takes place in these abysses has also been brought to notice by Mr. Murray. Among the clay from the bottom he found numerous minute spherical granules of native iron, which, as he suggests, are almost certainly of meteoric origin—fragments of those falling stars, which, coming to us from planetary space, burst into fragments when they rush into the denser layers of our atmosphere. In tracts where the growth of silt upon the sea-floor is excessively tardy, the fine particles, scattered by the dissipation of these meteorites, may remain in appreciable quantity. In this case, again, it is not needful to suppose that meteorites have disappeared over these ocean-depths more numerously than over other parts of the earth's surface. The iron granules have no doubt been as plentifully showered down elsewhere, though they can not be so readily detected in accumulating sediment. I know no recent discovery in physical geography more calculated to impress deeply the imagination than the testimony of this meteoric iron from the most distant abysses of the ocean. To be told that mud gathers on the floor of these abysses at an extremely slow rate, conveys but a vague notion of the tardiness of the process. But to learn that it gathers so slowly that the very star-dust which falls from outer space forms an appreciable part of it, brings home to us, as hardly anything else could do, the idea of undisturbed and excessively slow accumulation.

From all this evidence we may legitimately conclude that the pres-

ent land of the globe, though formed in great measure of marine formations, has never lain under the deep sea; but that its site must always have been near land. Even its thick marine limestones are the deposits of comparatively shallow water. Whether or not any trace of aboriginal land may now be discoverable, the characters of the most unequivocally marine formations bear emphatic testimony to this proximity of a terrestrial surface. The present continental ridges have probably always existed in some form, and as a corollary we may infer that the present deep ocean-basins likewise date from the remotest geological antiquity.

(*b.*) *Crystalline.*—While the greater part of the framework of the land has been slowly built up of sedimentary materials, it is abundantly varied by the occurrence of crystalline masses, many of which have been injected in a molten condition into rents underground, or have been poured out in lava-streams at the surface.

Without entering at all into geological detail, it will be enough for the present purpose to recognize the characters and origin of two great types of crystalline material which have been called respectively the Igneous and Metamorphic.

1. *Igneous.*—As the name denotes, igneous rocks have risen from the heated interior of the earth. In a modern volcano, lava ascends the central funnel, and, issuing from the lip of the crater or from lateral fissures, pours down the slopes of the cone in sheets of melted rock. The upper surface of the lava column within the volcano is kept in constant ebullition by the rise of steam through its mass. Every now and then a vast body of steam rushes out with a terrific explosion, scattering the melted lava into impalpable dust, and filling the air with ashes and stones, which descend in showers upon the surrounding country. At the surface, therefore, igneous rocks appear, partly as masses of congealed lava, and partly as more or less consolidated sheets of dust and stones. But beneath the surface there must be a downward prolongation of the lava column, which no doubt sends out veins into the rents of the subterranean rocks. We can suppose that the general aspect of the lava which consolidates at some depth will differ from that which solidifies above-ground.

As a result of the revolutions which the crust of the earth has undergone, the roots of many ancient volcanoes have been laid bare. We have been as it were admitted into the secrets of these subterranean laboratories of nature, and have learned much regarding the mechanism of volcanic action, which we could never have discovered from any modern volcano. Thus, while on the one hand we meet with beds of lava and consolidated volcanic ashes, which were undoubtedly erupted at the surface of the ground in ancient periods, and were subsequently buried deep beneath sedimentary accumulations now removed, on the other hand, we find masses of igneous rock which certainly never came near the surface, but must have been arrested in their ascent from be-

low, while still at a great depth, and have been laid bare to the light after the removal of the pile of rock under which they originally lay.

By noting these and other characters, geologists have learned that, besides the regions of still active volcanoes, there are few large areas of the earth's surface where proofs of former volcanic action or of the protrusion of igneous rocks may not be found. The crust of the earth, crumpled and fissured, has been, so to speak, perforated and cemented together by molten matter driven up from below.

2. *Metamorphic.*—The sedimentary rocks of the land have undergone many changes since their formation, some of which are still far from being satisfactorily accounted for. One of these changes is expressed by the term *Metamorphism*, and the rocks which have undergone this process are called *Metamorphic*. It seems to have taken place under widely different conditions, being sometimes confined to small local tracts, at other times extending across a large portion of a continent. It consists in the rearrangement of the component materials of rocks, and notably in their recrystallization along particular lines or laminæ. It is usually associated with evidence of great pressure; the rocks in which it occurs having been corrugated and crumpled, not only in vast folds, which extend across whole mountains, but even in such minute puckerings as can only be observed with the microscope. It shows itself more particularly among the older geological formations, or those which have been once deeply buried under more recent masses of rock, and have been exposed as the result of the removal of these overlying accumulations. The original characters of the sandstones, shales, grits, conglomerates, and limestones, of which no doubt these metamorphic masses once consisted, have been almost entirely effaced and have given place to that peculiar crystalline laminated or foliated structure so distinctively a result of metamorphism.

An attentive examination of a metamorphic region shows that here and there the alteration and recrystallization have proceeded so far that the rocks graduate into granites and other so-called igneous rocks. A series of specimens may be collected showing unaltered or at least quite recognizable sedimentry rocks at the one end, and thoroughly crystalline igneous rocks at the other. Thus the remarkable fact is brought home to the mind that ordinary sandstones, shales, and other sedimentary materials may in the course of ages be converted by underground changes into crystalline granite. The framework of the land, besides being knit together by masses of igneous rock intruded from below, has been strengthened by the welding and crystallization of its lowest rocks. It is these rocks which rise along the central crests of mountain-chains, where, after the lapse of ages, they have been uncovered and laid bare, to be bleached and shattered by frost and storm. —*Proceedings of the Royal Geographical Society.*

SKETCH OF PROFESSOR DANIEL VAUGHAN.

WE have already printed in our May number a brief sketch of the life of Professor Vaughan, with the particulars of the painful circumstances attending his death, and a list of his more important scientific papers. That sketch comprises the history of Vaughan's life, so far as it is known, and there remains nothing more to add to it.

It is not a little singular that among the property which he left only one piece of unpublished MS. was found. Remarking on this fact, Mr. Richard Nelson writes in the "Cincinnati Commercial": "As early as 1857 he had occasion to complain that one of his discoveries had been claimed by a prominent scientist. That made him suspicious, and, as a result of his solitary life, suspicion, like a disease, grew upon him to that extent that at one time his intimate friends feared it would overpower his giant intellect. To prevent the recurrence of the annoyance he afterward chose to store away in his wonderfully capacious and retentive memory facts, principles, and figures, till the opportune moment of publication arrived, and then, instead of sending his manuscript to the publishers, he had his articles printed and simultaneously mailed to the publishers and distinguished scientists in various parts of the world. These are the printed articles found among his effects."

The unpublished MS. mentioned above was on "The Origin of the Asteroids," and is marked by all the best characteristics of the author's style. While extremely brief, it treats the subject thoroughly. This paper is printed in our August Miscellany.

We have been called upon to qualify somewhat the statements made in the "Monthly" reflecting upon the citizens of Cincinnati for neglecting this man in his poverty, and leaving him to die in want. It turns out that Vaughan was a man destitute of common sense in the matter of taking care of himself, and that he was perverse in not allowing others to assist him. With his penury he was eccentric, and carefully secluded himself from attention, so that it was difficult to find him. It is said there were many who would gladly have assisted him, and that, too, in a way not to wound his feelings, if he had given them the opportunity, but that he obstinately refused to receive assistance. He was probably intractable in this respect, for which there may have been much excuse, for he may have felt that he was entitled to something better than charity, and, if he could not get what was his due, he would not take pittances. Perhaps, if there had been more solicitude about him, more might have been done for him; but it is quite probable that Cincinnati is not worse than other cities in its want of active sympathy for the suffering.

EDITOR'S TABLE.

THE BENNETT EXPEDITION TO THE NORTH POLE.

THE unknown spaces of the earth's surface are being rapidly narrowed by the enterprise of indefatigable explorers. Some considerable patches remain that have not been penetrated, but their collective area is relatively small. There is a large region in the interior of Australia that has not been traversed, owing to the absence of water and vegetation. Central Africa is the field where the geographical discoverer has recently made his most brilliant conquests, both by narrowing the outline of the unknown region, and by the importance of the knowledge that has been gained. Less than half a century ago inner Africa was supposed to be in a great measure an arid and unproductive desert; but the explorations of Livingstone and Stanley have proved it to be well watered, fertile, and densely populated. There has been less success with Arctic exploration, though it has been vigorously pushed for the last fifty years. Latitude 83° 26′ is the northernmost point hitherto reached by any explorer. This leaves an unpenetrated blank surrounding the north pole which at the narrowest point is about 800 miles across. There is little promise of any commercial utility that can come from getting access to this frigid region, but it is enough that it is a mystery which the whole civilized world has determined, if possible, to clear up, and in doing this the rivalries of national enterprise have been called into active play.

It is fortunate for geographical progress that the proprietor of the "New York Herald," Mr. James Gordon Bennett, not altogether satisfied with the excitements of yacht-racing, has developed an ambition in the direction of exploring unknown tracts of the earth's surface. He has spent a good deal of money on mid-Africa with highly satisfactory results, and now turns the princely revenues of his newspaper into a channel for the promotion of Arctic research. It is an expensive business, as the cost of Arctic expeditions has increased from $30,000, three hundred years ago, to $4,166,665 for the Franklin expeditions of 1848–'54. Mr. Bennett, after furnishing the necessary funds, and preparing the expedition, has made it a national affair by requesting the United States Government to take charge of it. By act of Congress it has been put in control of naval officers, and is cared for by the Navy Department. Besides these peculiarities of the project, it is novel as being the first Arctic expedition fitted out from the west coast of the continent, and which proposes to push forward to the north pole by the way of Behring Strait. According to Lieutenant De Long, commander of the Jeannette, which carries the exploring party, no vessel has penetrated farther north by this route than latitude 71°. Beyond that parallel the explorers will encounter a hitherto unobserved region.

A new element comes into play in this venture which has been thus far regarded by Arctic navigators as one of peril. In the other routes that have been taken to reach the pole the currents set downward, so that if the adventurers have to abandon their ship and take to the ice they have a chance of being brought back, as was marvelously exemplified by the ride of Tyson's party. But on the Pacific side there is a current of water known as the Kuro Shiwo, or Japanese Warm-Stream, a branch of

which is known to enter the Arctic Sea through Behring Strait, and is believed to emerge on the other side through Baffin's Bay. The drift of ice on this side is consequently northward, and the danger is that it will cut off the retreat in case of accident to the ship by which the party is compelled to take to the ice.

Of course the object of the expedition is to reach the north pole, but, even if it fails, there are subsidiary objects also to be accomplished. It may be expected, at any rate, that the unknown Arctic area will be reduced in dimensions, and there will be the opportunity of scientific observations in places as yet unexplored. The magnetic conditions north of the magnetic pole will be examined. There will be geological and mineralogical observations, and information collected with reference to the fauna and flora of the Arctic regions. Systematic attention will also be given to meteorology, in the hope of getting further data for elucidating the laws of storms.

The scientists of the Western coasts, as is very natural, have taken a deep interest in this first Arctic expedition from their side, and that has so many special features of importance. A meeting of the Academy of Sciences in San Francisco was convened June 16th, for the special purpose of giving a reception to Lieutenant De Long and the staff of the Bennett expedition. A paper on Arctic exploration was read by Dr. A. B. Stout, and remarks were made upon various connected topics by gentlemen present. Lieutenant De Long spoke, but only to say that he had very little to say in regard to what they were going to do. They did not sufficiently know themselves, and hoped to be better qualified to talk satisfactorily upon their return. Mr. Charles Wolcott Brooks made some interesting observations regarding the ethnological possibilities of the Arctic regions which we here subjoin: "In offering his word of kind encouragement, he remarked that men who use obstacles as stepping-stones to success are apt to win; and he but expressed the universal desire of all ethnologists that Lieutenant De Long and his brave comrades should overcome every barrier that the Frost King might impose as an obstacle to their success. As ethnologists, we all feel great interest in the existence of an Arctic Continent, and earnestly desire to know if it is, or can be, inhabited. In a world governed by mathematical law, whose every atom is geometrically correct, and subject to mathematical proof, we may reasonably judge of the unknown by what we can see, cautiously using the great law of analogy as our guide. If we should judge of the ultimate atom, or the most distant orb in space, we may study for that purpose some object around us, or our globe taken as a whole. He who has watched the organization of crystalline forms under electric currents has seen the operation of the same law which has formed the solid part of the earth we live on. In its early and plastic condition it was a sphere like the dew-drop, but, with the constant currents of organizing magnetism, it has assumed a crystalline form, and to-day its solid exterior, were its oceans emptied and removed, would present the polyhedron. If we carefully examine the almost universal features of all land known to us, we find a prevailing form wherever we turn. Each territorial area of magnitude seems to have an appendage trending southward. Thus, south of the large continent of North America, we find that leg-of-mutton or *pend d'oreille* form of South America. Beneath Europe rests a similar shaped area of land in the continent of Africa, and south of Asia is Australia and the Polynesian or Spice Islands. The same relative position of land is general among many island groups, and all peninsulas seem also to point southward, such as Kamtchatka, Alaska, Lower California, Florida, Nova

Scotia, Hindostan, etc., and all such forms have larger bodies of land to their north. Now, if we apply this rule, by turning the north pole of a globe toward us, we readily see at a glance that Greenland, which is known to us, may bear to an unknown Arctic Continent the same relation that South America does to North America, or Africa to Europe. Hence it is perfectly logical to infer, by the great analogy of nature, that an Arctic Continent exists beneath the north pole, extending three and a half to four degrees south from the northern axis of the world. As previous Arctic expeditions have advanced to 83° 26′ north latitude—or within 394 miles of the pole—the distance thence to such a continent would not exceed 150 to 180 miles. This intervening space, however, is quite difficult to traverse, as it is represented to present a very rough surface. If the sea, during the height of a gale, when waves run mountains-high, were instantly frozen, it would present much the appearance here encountered. Now, for ethnologists, the question is, Can an Arctic Continent be inhabited, should one exist? This may be met by the already expressed surmise that the latitude of 78° is about the point of lowest mean temperature. The earth is about thirty-seven miles more in diameter at the equator than from pole to pole, having enlarged at one point and flattened at another, because of its revolving motion. Now, it is well known that lower temperatures are encountered as we ascend great altitudes, and the depression at the poles may, by lessening the distance of the surface from the earth's center, afford a warmer temperature, which will enable the hardy Esquimaux, Ainos, or some hyperborean race, to exist upon an Arctic Continent. Should such prove to be the case, and our good friends discover any races there to us unknown, we shall look to them to resurrect us a specimen skull of some departed inhabitant."

THE PRINCE IMPERIAL.

Much regret is expressed at the sad end of the late descendant of the Napoleons and heir-apparent to the throne of France; and much sympathy has also been awakened for the exiled and widowed mother now made childless. The bereaved woman is entitled to the same sympathetic consideration as any other poor widow who has lost an only child; for, though in her case there may be a peculiar bitterness in the crushing of ambitious hopes, she has yet the mitigations of royal condolence, and the assurance that her griefs are shared by sympathetic multitudes. As for the dead Prince, we might say that his premature cutting off is just as deplorable as the killing of other young soldiers in the common fortunes of war.

But is this quite true? At any rate, if it is a blessed thing to lay down one's life for one's country, is not the amiable young Prince to be deemed fortunate, for certainly his death is the greatest boon that it would be possible for the French nation now to receive? Again, according to the code of military honor, he is to be congratulated in having lost his life in war, whether his country benefited or lost by it; and especially so as the other Napoleons have died peacefully and ingloriously in their beds, while it has been reserved for the last of the line to perish, if not on the field of battle, at least by violence and in war. Belonging to a race of adventurers, he fitly died as an adventurer; and, although the manner of his going was not very dignified, history will still be able to say that one Bonaparte was sacrificed to the vocation to which they were all devoted.

There is, however, one aspect of this transaction that may be referred to as an illustration of the selfish brutality of the common ethics of war. When the military system is arraigned as the great anomaly of civilization, and war as the most stupendous curse of humanity, we are told that nations

must defend themselves, and that war is therefore a necessary evil, to be avoided whenever possible, and always mitigated to the utmost in its sufferings and its horrible waste of life. And yet when men go into it in cold blood as a business, regardless of its justice, and purely for the promotion of a selfish ambition, their conduct still meets with unbounded applause. It is said to be to the credit of the young Prince that he generously offered his services to England to fight the Zulus; but what business had this young Frenchman with the Zulu war? What had these distant Africans ever done, that he should desire to join in the work of killing them? He not only mixed up with what was none of his concern, but he espoused the cause of the wanton aggressor, for a greater outrage was never perpetrated than this British invasion of the Zulu people. But it is in accordance with military traditions and usages for ambitious men to seize any opportunity of making their mark. The Count of Paris came over to have a hand in our own glorious civil war, took sides, and went into the business of killing Southerners for the noble purpose of acquiring military prestige that might commend him to the French, and thus increase his chances of being accepted for the throne of that nation. The Prince Imperial "went to war" for the same purpose, that he might make a military name, and thus improve his chances of getting control of the French army at some future crisis, and play the despot like his predecessors. He followed a detestable practice for a villainous purpose, and got his just reward.

"AMERICA'S PLACE IN HISTORY."

UNDER this title, Mr. John Fiske, of Cambridge, Massachusetts, formerly lecturer on Philosophy in Harvard University, has prepared a course of popular lectures which will be found worthy the attention of such associations as can appreciate first-rate intellectual work. Mr. Fiske is author of the "Cosmic Philosophy," and a thorough student of the modern tendencies of thought. He gave these lectures in Boston not long ago, and they made so excellent an impression that he was called to repeat them in London, and left early in June for that purpose. Mr. Fiske is well prepared by his philosophical and historical studies to give to the problem he has taken up an original and independent treatment. Familiar with the principles of social evolution, and having given much attention to the study of races, and to ethnological interactions in the progress of modern society, he is well prepared to handle the large and complex questions involved in the settlement of America, the organization of colonial institutions, the establishment of the American Republic, and the development of free government on this continent. The prospectus of this course of lectures is before us, and it is rich in topics that must deeply interest all thoughtful Americans. These are the sort of lectures that deserve encouragement and are worth working for.

THE senior editor of this magazine also proposes to betake himself somewhat to his old business of lecturing during the coming season. For particulars address E. L. Youmans, office of "The Popular Science Monthly," New York.

LITERARY NOTICES.

THE INTERNATIONAL SCIENTIFIC SERIES, No. XXVII. THE HUMAN SPECIES. By A. DE QUATREFAGES, Professor of Anthropology in the Museum of Natural History, Paris. New York: D. Appleton & Co. Pp. 498. Price, $1.75.

THE accomplished French anthropologist has here produced a remarkably attractive book. It is written with all that clearness and vivacity of manner for which

skilful literary Frenchmen are remarkable, and the translator has well reproduced the art of the author. This, however, is but an incidental though important trait of the volume; its interest centers in the scientific treatment of a vast subject, in the admirable classification of its materials, the incisiveness of the dialectics, and the wealth of information to elucidate and illuminate a great branch of inquiry. De Quatrefages is, moreover, a man of moderate views, a cautious and disciplined investigator, and who, by long familiarity with his subject, speaks with authority, and may be trusted in the representation of his facts.

His work is divided into ten Books, the first of which consists of eleven chapters, in which he discusses in its various aspects the "Unity of the Human Species." The anthropological method is first treated with a general statement of anthropological doctrines. The problem of species and race in the natural sciences is then taken up, and the nature and extent of variations in animal and vegetable races, with their applications to man, are considered. The fusion of characters, and the crossing of races and species in the animal and vegetable kingdoms, are next dealt with, and the conclusions applied to the human race. The human groups obey the laws of crossing, and from his wide survey of the facts the author arrives at the conclusion that all men belong to the same species, and that there is but one species of man.

Book II. takes up the vexed question of the "Origin of the Human Species," which is dealt with in two chapters. There is here a sharp discussion of Darwinism, in which the author refuses to accept the conclusions of the British zoölogist. He admits the principle of natural selection as both a true cause and an important agency in producing the changes of the living world; but he totally denies that this principle is adequate to produce transformations of species or to originate new species. He praises Darwin's accomplishments as a biologist, and acknowledges the indebtedness of science to his investigations, but will not for a moment recognize that he has accounted for the origin of man. On this question he takes the conservative side, and, while cordially commending the vigorous work of advanced naturalists, and recognizing that valuable results may flow from it, he still avows himself as belonging to the old school. Of the origin of life the author says we know nothing, and "all who wish to remain faithful to true science will accept the existence and succession of species as a primordial fact. He will apply to all what Darwin applies to his single *prototype*." We will refer to this matter again presently.

Book III. takes up the question of the "Antiquity of the Human Species," and gives a succinct account of the relation of man to present and past geological epochs in two chapters.

Book IV. devotes also two chapters to the "Original Localization of the Human Species," and, of course, raises the question of centers of creation and unity or plurality of origins. Agassiz is taken as the ablest representative of the latter doctrine, which is criticised by Professor De Quatrefages with great force. One of the most interesting problems that will have to be worked out one of these days is that of the mental bias and incompetency of judgment acquired by scientific men as a result of their special branches of study. Professor De Quatrefages gives an interesting illustration of this in the case of Agassiz. He says: "There are singular points of resemblance and no less striking contrasts between Agassiz and the most extravagant disciples of Darwin. The illustrious author of the 'Essay on Classification' is as exclusive a morphologist as the latter: neither in his opinion nor in theirs does the idea of filiation form any connection with that of species; he declares, as they do, that the questions of crossing, of constant or limited fertility, have no real interest. We are justified in attributing these opinions, so strange in such an eminent zoölogist as Agassiz, to the nature of his early works. It is well known that he commenced his career with his celebrated researches upon fossil fishes. We have already remarked upon the influence which is almost inevitably exercised by fossils where form alone has to be considered, where nothing calls attention to the genealogical connection of beings, and where we meet with neither parents nor offspring."

Having given illustrations of the way Agassiz, in the heat of controversy, was led on to untenable positions so that at last he denied even the filiations of languages, Professor De Quatrefages proceeds: "Agassiz, when he had arrived at this point, must have felt that he had lost himself, and that in trying to harmonize the idea of a single human species with that of several races of distinct origin he was entering an endless labyrinth. His last work betrays the signs of this embarrassment only too clearly. It is probably in the hope of escaping from it that the author has finally even denied the existence of species. After having again rejected the criterion drawn from crossing and degrees of fertility, he adds: 'With it disappears in its turn the pretended reality of species as opposed to the mode of existence of genera, families, orders, classes, and branches. Reality of existence is in fact possessed by individuals alone.' Thus from adhering solely to morphology from a disregard of the physiological side of the question, from having allowed themselves to be guided by a logic which is only founded upon incomplete data, Agassiz and Darwin have arrived at a similar result. Both have disregarded this great fact intelligible to common sense, demonstrated by science, and which governs everything in zoölogy as it does in botany, the division, namely, of organized beings into elementary and fundamental groups which propagate in space and time. But Darwin, starting from the phenomena of *variations* which are presented by these beings, considers species only as races. Agassiz, entirely preoccupied with the phenomena of *fixity*, finally considers individuals only as existing in living nature."

This is the proper place to suggest that De Quatrefages himself is perhaps open to criticism from the point of view of studies that disturb the judgment. While there is force in the point he makes against Darwinism, that natural selection is insufficient to account for evolution, the same thing is pointed out by eminent evolutionists, and Darwin himself has admitted that he at first made too much of the principle. De Quatrefages makes the common mistake of considering Darwinism and evolution as the same thing. We should say that the logical fault of De Quatrefages is that he does not allow sufficient weight to that already overwhelming consensus of proofs, and which is every day becoming stronger, that evolution is a great fact of nature, which must be accepted in its interpretation whatever outstanding difficulties remain yet to be cleared up.

Book V., on the "Peopling of the Globe," deals with the interesting subject of the migration of populations by sea and land. Book VI. takes up the "Acclimatization of the Human Species," and deals with the influence of conditions on life and race. Book VII. discusses "Primitive Man—Formation of the Human Races." In Book VIII. four interesting chapters are given to "Fossil Human Races." Book IX. considers the "Physical Characters of Present Human Races," anatomical, physiological, and pathological. Book X. closes the work by an "Analysis of the Psychological Characters of the Human Species," including its intellectual, moral, and religious characters.

To those in want of a well-digested summary of anthropological science, done in a most readable form, this volume may be freely commended.

A PRACTICAL TREATISE ON THE COMBUSTION OF COAL, INCLUDING DESCRIPTIONS OF VARIOUS MECHANICAL DEVICES FOR THE ECONOMIC GENERATION OF HEAT BY THE COMBUSTION OF FUEL, WHETHER SOLID, LIQUID, OR GASEOUS. By WILLIAM M. BARR. Indianapolis: Zohn Brothers. Pp. 306. Price, $2.50.

THIS seems a very well-digested compilation of a large amount of useful information upon a subject of much technical interest and importance. Coal has already come into so extensive use as a source of heat, both for warmth in private houses and as a motive power in manufactures, and its consumption for these ends is certain to be so greatly increased in future, that the question of the best methods of using it, in various circumstances, in order to make its force more perfectly available, is one of much practical moment. It is a subject well fit to be treated separately, and Mr. Barr's volume goes over it in a quite detailed and ample way. No better idea of the fullness of the work can be gained than by giving an inventory of its

chapters. The first is preliminary, on the physical properties and sources and formation of coal. This is followed by "The Atmosphere," "Fuels," "Analysis of Coal," "Combustion," "Air required for Furnace Combustion," "The Furnace," "Products of Combustion," "Thermal Power of Fuels," "Heat," "The Construction of Furnaces," "Mechanical Firing," "Spontaneous Combustion of Coal," "Coal-Dust Fuel," "Liquid Fuel," "Gaseous Fuel," "Utilizing Waste Gases from the Furnace," "A. Ponsard's Process and Apparatus for generating Gaseous Fuel."

MAN'S MORAL NATURE: AN ESSAY. By RICHARD MAURICE BUCKE, M. D., Medical Superintendent of the Asylum for the Insane, London, Ontario. New York: G. P. Putnam's Sons. Pp. 200. Price, $1.50.

THE author of this book, who ought to know the most about it, indicated its scope and the purpose he had in writing it in the following introductory passage:

> The object of this essay is to discuss the moral nature—to point out, in the first place, its general relation to the other groups of functions belonging to, or rather making up, the individual man, and also its relations to man's environment. Secondly, to show its radical separation from these other groups of functions; then to attempt to decide of what organ it is a function—to consider whether it is a fixed quantity, or whether, like the active nature and the intellectual nature, it is in course of development. And, if the moral nature is progressive, to try to find out what the essential nature of this progress is—upon what basis the progress itself rests—the direction of the progress in the past and in the future—its causes—its history—and the law of it—and to point out the conclusions which can be drawn from this progress as to the character of the universe in which we live.

We hardly think, however, that the work can be classed among important contributions to the progress of ethical science. It seems to stand, in fact, in the same relation to the constitution of the moral world that the old doctrine of the four elements—fire, air, earth, and water—stood to the constitution of the physical world. There were ingenuity and a crude utility, when nothing was known of nature, in this conception of four elemental constituents by the endless commixture of which all natural things were accounted for, but it would not be a step forward to revive it now. Dr. Bucke takes, as the foundation of his ethical system, the four simple moral elements—faith, love, hate, and fear—and, by combinations of these with each other, and with still other ideas, he aims to solve all moral problems and account for all moral phenomena. He is a physician, and links his theory with physiological and anatomical science, by assuming that the sympathetic system is the nervous center of the moral nature. He gives woodcuts of the ganglionic chains, of the cerebro-spinal and great sympathetic nerves, accompanied with an interesting account of their anatomical structure and physiological functions, and he assumes the moral relations of the sympathetic system because of its intimate association with the emotional life.

THE REIGN OF THE STOICS: HISTORY, RELIGION, MAXIMS OF SELF-CONTROL, SELF-CULTURE, JUSTICE, PHILOSOPHY. With Citations of Authors quoted from each page. By FREDERICK MAY HOLLAND. New York: Charles P. Somerby. Pp. 248. Price, $1.25.

MR. MILL, in his celebrated St. Andrew's defense of classical studies in modern education, in replying to the charge that there is little valuable information to be got out of old Greek and Latin books, declared that ancient literature contains a great deal of "the wisdom of life" which may be profitably studied in these times. He did not say what there was about this wonderful wisdom that should make it necessary, after two thousand years of further experience, and all the vast developments of modern knowledge, that our youth should be compelled to learn two dead languages in order to arrive at it. Precious, indeed, must be that "wisdom of life" which is incapable of being transferred from one form of speech to another. The compiler of the volume before us quite fails to see Mr. Mill's point, and has gone about the task of importing the said wisdom of the ancients into the English tongue, so that it may be made available by multitudes who know nothing of the classical languages. The first chapter is a kind of historical essay relating to the ancient Stoical moralists. Chapter II. is devoted to religion; Chapter III. to maxims of self-control; Chapter IV. to maxims of self-culture; Chapter V. to maxims of benevo-

lence; Chapter VI. to maxims of justice; and Chapter VII. is a kind of essay on the ancient philosophy. The compiler has raked together from all sources a mass of fragmentary proverbs, aphorisms, sentiments, and wise sayings, which are no doubt quite as sound and instructive, but not half as pungent and readable, as the saws of Sancho Panza. On the whole, we think that Mill is about right, and that people will appreciate this wisdom a great deal higher after they have mastered a couple of languages in order to get at it.

THE TEMPERAMENTS; OR, THE VARIETIES OF PHYSICAL CONSTITUTION IN MAN CONSIDERED IN THEIR RELATIONS TO MENTAL CHARACTER AND THE PRACTICAL AFFAIRS OF LIFE. By D. H. JACQUES, M. D. New York: S. R. Wells & Co. 1878. Pp. 239. $1.50.

THE editor of this volume, in the introduction, remarks that the "literature of the temperaments is very scanty." The reason of this doubtless is, that scientific investigators have not hitherto regarded the temperaments as a very fruitful field of study. According to Dr. Jacques, however, there is no study, not even, perhaps, phrenology itself, which can be of greater service to us in acquiring a knowledge of ourselves and our fellow men. Those who may happen to coincide with this view, and suppose that they can gain "practical guidance in the affairs of life" by closely observing differences of temperament, will do well to consult Dr. Jacques's well-written little work.

COLOR-BLINDNESS, ITS DANGERS AND ITS DETECTION. By B. JOY JEFFRIES, A. M., M. D. Boston: Houghton, Osgood & Co. Pp. 312. Price, $2.

THIS subject, which is one of much scientific interest and practical importance, has engaged the attention of many inquirers during the past and present generations. That defect of vision by which certain colors can not be discriminated, and by which one is mistaken for another, and which is now well established as congenital and as very common, has no doubt existed at all times, though its detection is modern and its scientific elucidation comparatively recent. The first well-authenticated case of color-blindness was of an English shoemaker, named Harris, one hundred years ago. But the first marked instance attracting general attention was that of the English chemist, Dalton, who described his own case in 1794, so that this chromatic defect went for some time under the name of Daltonism. The tests of this deficiency have now been carefully worked out and observations made in different countries upon great numbers of persons, bringing out the general result, that about four per cent. of the persons inspected suffer from this defect in a greater or less degree, some being incapable of recognizing one color, and some another. Dr. Jeffries treats the subject systematically and fully in his volume, giving great numbers of cases and digesting all the results of the investigation in different countries. It is found that this failure of vision is so frequent that it has been necessary to institute government inspection of men in all those public employments where erroneous vision might lead to danger, as where colored signals are employed upon railroads and in navigation. In Chapter XXIII. of his book, Dr. Jeffries gives an account of the European and Massachusetts legislation which has been resorted to, to obtain security from errors of this kind.

MONEY, TRADE, AND INDUSTRY. By FRANCIS A. WALKER, Professor of Political Economy and History in the Sheffield Scientific School of Yale College. New York: Henry Holt & Co. Pp. 339. Price, $1.25.

WE have here from the pen of the Superintendent of the United States Census, and author of "The Statistical Atlas of the United States," a very important contribution to certain aspects of political economy that are of the highest moment to the people of the United States. Professor Walker published a work on "Money" last year, written from the historical standpoint, and designed to introduce the student to the literature of the subject. The present work aims to make a direct popular statement of principles, without giving the history of their derivation; and it differs from the other book also by taking in the relations of money to trade and industry. The volume is therefore practical in its scope, and has been adapted, with excellent judgment, both to the popular capacity of apprehending economical inquiries and to the most urgent

wants of this country at the present time for sound information. Whatever may be the unattractiveness of the "dismal science," we are satisfied that a large share of it is due to the culpable dullness of writers on economics. If a book upon money is stupid, the author must take the responsibility, for his subject is in his favor, and he may count upon the interest of his reader if he does not succeed in extinguishing it. Professor Walker writes with a vigorous directness, a clearness of perception, and an artistic skill in the use of examples and illustrations, which give a keen pleasure to the reader, and make every chapter of his book entertaining as well as instructive. His views are stated with an epigrammatic point and argumentative force that will make the perusal of his book a pleasure to all into whose hands it may fall. Embroiled as we are in this country in conflicts of opinion upon all aspects of the money question—coinage and paper currency, mono-metalism and bi-metalism, depreciation and appreciation, expansion and contraction, high and low interest, national issues and banking agencies, and scores of other monetary problems—nothing is more needed than able popular presentations of the principles that underlie all this complex system of financial phenomena, and we have seen no book better adapted to clarify the public mind upon these subjects than this of Professor Walker.

BIRDS OF THE COLORADO VALLEY. By ELLIOTT COUES. With numerous Illustrations. Washington: Government Printing-Office. 1878. Pp. 823.

IN preparing this work, Dr. Coues has undertaken a vast amount of labor. The whole subject of the bibliography of North American ornithology and of the synonomy of North American birds has been worked up anew from the very bottom, and nothing is given at second hand. Not only the birds of the Colorado Valley, but also all others of North America, are thus exhaustively treated. The popular character of this treatise is very marked. "Respecting the biographies or *life history* of the birds which constitute the main text of the present volume," writes Professor Hayden, "the author's view, that this portion of the subject should be so far divested of technicality as to meet the *tastes and wants of the public*, rather than the scientific requirements of the schoolmen in ornithology, will doubtless meet with general and emphatic approval." The volume before us forms Part I. of the treatise, "Passeres to Laniidæ."

AIDS TO FAMILY GOVERNMENT: OR, FROM THE CRADLE TO THE SCHOOL, ACCORDING TO FROEBEL. By BERTHA MAYER. Translated from the German by M. L. HOLBROOK, M. D. WITH AN ESSAY ON THE RIGHTS OF CHILDREN AND THE TRUE PRINCIPLES OF FAMILY GOVERNMENT. By HERBERT SPENCER. New York: M. L. Holbrook & Co. Pp. 208.

THIS book mainly consists of a translation of a little treatise on early education, said to be very popular in Germany. It is devoted to Pestalozzi, Froebel, and Kindergartens, and some useful hints may be picked out of it, though it will be chiefly useful in swelling the tide of Kindergarten literature, which is just now in fashion. The name of Herbert Spencer appears upon the cover of the title-page as author of a part of the book, and there are a dozen pages of extracts from him at the end. But from which of his works they are taken, or in what connection they are to be found, is not stated. The quotations, however, on the rights of children, are from a volume printed by Spencer twenty-nine years ago, parts of which he has since disavowed as no longer representing his views, and among them is the chapter on the rights of children.

THE BENEFICIAL INFLUENCE OF PLANTS. By J. M. ANDERS, M. D., Ph. D. Pp. 12.

THIS paper treats of the old question of the influence of plants in houses on the conditions of health. The author is inclined to agree with Pettenkofer, that, as decomposers of carbonic-acid gas or as generators of ozone, plants in rooms are really of little or no value; but, as a means of supplying moisture to the air of furnace-heated houses by the process of transpiration, they become important agents in promoting the health of the inmates. This conclusion is based on the writer's own investigations, the results of which are given in the paper.

PUBLICATIONS RECEIVED.

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The Round Trip. By John Codman. New York: Putnam's Sons. 1879. Pp. 331. $1.50.

Lectures on the History of England. By M. J. Guest. London and New York: Macmillan. 1879. Pp. 568. $1.75.

Outlines of Field Geology. By A. Geikie. London and New York: Macmillan. 1879. Pp. 222. $1.

Long Life, and how to reach it. By Joseph G. Richardson, M. D. Philadelphia: Lindsay & Blakiston. 1879. Pp. 160. 50 cents.

Cultivation of the Senses. Philadelphia: Eldridge & Brother. Pp. 96. 50 cents.

Is Life worth living? By W. H. Mallock. New York: Putnam's Sons. 1879. Pp. 323. $1.50.

Relations of Mind and Brain. By H. Calderwood. London and New York: Macmillan. 1879. Pp. 455. $4.

Botanical Text-Book: Practical Botany. By A. Gray, LL. D. New York: Ivison, Blakeman, Taylor & Co. 1879. Pp. 442.

Geological Survey of Ohio. Vol. III. Geology and Paleontology. Columbus, O.: Nevins & Myers. 1878. Pp. 958.

Scientific Grammar of the English Language. By W. Colegrove, A. M. New York: Authors' Publishing Company. 1879. Pp. 362.

Survey of the Northwestern Lakes and the Mississippi River. In charge of C. B. Comstock and H. M. Adams. Washington: Government Printing-Office. 1879. Pp. 62.

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Thermo-dynamics. By H. G. Eddy. New York: Van Nostrand. 1879. Pp. 182.

The Position: A Thesis. By Cyrus the Elamite. Louisville, Ky.: R. R. Bolling & Co. 1879. Pp. 65.

Form of Seeds as a Factor in Natural Selection. By R. G. C. Stearne. From the "American Naturalist." Pp. 9.

American Nervousness. By G. M. Beard, M. D. From the Virginia "Medical Monthly." 1879. Pp. 24.

The Perihelia Crisis. By R. Mansill. Rock Island, Ill. 1879. Pp. 42. 50 cents.

Effects of Frost of Plants. By T. J. Burrell. Pp. 9.

Seed-Breeding. By G. L. Sturtevant, M. D. From "Report of Secretary of the Connecticut Board of Agriculture." Pp. 28.

Logical Basis of the High Potency Question. By S. Potter, M. D. From the "Hahnemannian Monthly." Pp. 25.

Report of Central Park Menagerie (1878). New York: Brown print. 1879. Pp. 30.

Life and Work of Joseph Henry. By F. L. Pope. From "Journal of the American Electrical Society." Pp. 31.

Meteoric Fire-Balls. By D. Kirkwood. From "Proceedings of the American Philosophical Society." Pp. 8.

New Jurassic Mammal. By O. C. Marsh. From "American Journal of Science and Arts." Pp. 2.

Geology of the Diamantiferous Region of the Province of Paraná, Brazil. By O. A. Derby. Pp. 7.

Distribution of Heat in the Spectra of Various Sources of Radiation. By W. W. Jacques. With Plates. Cambridge: University Press. Pp. 24.

"New York Herald" Weather Service (1877, 1878, 1879). Pp. 34.

POPULAR MISCELLANY.

Bodily Injuries from Falling Meteors.—In view of the estimate made by Mr. G. J. Stoney in the paper elsewhere published in the present number of the Monthly, the following observations by Professor H. Karsten, which we take from "Die Natur," can not fail to be interesting.

The accounts recently published, of the falling of sundry small meteorites in the vicinity of men or even upon their persons, have vividly recalled to my mind another instance, as I conceive, of this phenomenon. In this case a man was wounded in such a way as to lead the bystanders to conclude that he had been wounded by a pistol-ball, though the most thorough search failed to discover any evidence confirmatory of that opinion.

The reader will perhaps remember how, according to the "Cologne Zeitung," on August 29th of year before last, at half-past nine in the morning, a certain married couple living in the house No. 32 Neumarkt, in that city, were startled by a small stone falling through the open window into their room. "The wife ran and picked it up—a black-gray, prismatic stone of the size of a small bean; but, as it was red-hot and burned the tips of her fingers, she quickly dropped it again. Some minutes later the husband again took it up and found it to be still so hot that he could hardly hold it in his hand." This stone, which was immediately taken to the editor's office, was by all recognized as a meteorite.

Shortly before this, at Hanau, a boy was hit on the thumb in the open fields by a small, hot, falling stone; this, too, was supposed to be a meteorite. Unfortunately, it was never found.

At Schaffhausen, on the 2d of October, 1875, while a man was trundling a cart from the village of Beringen to Neuhausen, hence while going nearly due east, his right forearm was perforated from front to back as though by a musket-ball. The man was in the company of his brother and an acquaintance. At the moment of receiving the wound he heard a peculiar whirr as of a ball, but his companions say that they heard nothing. They all three searched high and low all around to discover the one who had fired the ball, but in vain, though the high-

way in which they were traveling ran straight through the open, level fields; neither was any one to be seen on the railway lying at no great distance to the right. Shortly after the occurrence the train from Neuhausen passed by. At some distance on the left are vineyards, where a few laborers were seen, but none of them had firearms, and even if they had they could not have sent a ball as far as the highway. It may be added that the wounded man is a peaceable fellow, having no enemies, so far as he knows. Besides, the missile—as is to be seen from the wound—came from the front, where no human being was to be seen on the broad, straight highway. The anterior wound was two inches inside of and two inches above the capitulum radii, and the posterior wound, which was only five millimetres in diameter, was two inches inside of and one and one third inch above the inner condyle of the ulna. The physician who attended to the case asked my opinion about this enigmatical occurrence; and, on my attributing it either to an air-gun or to a meteorite, he rejected both hypotheses. It could not have been an air-gun, he said, because no such instrument had ever been heard of in that locality; and because, even if such an instrument had been used, no one after discharging it could have concealed himself, owing to the nature of the ground, as already described. As for meteorites, no one had ever known of people being wounded by them. I was not prepared to prove my second hypothesis or to strengthen it by citing analogous instances, though authors had often recorded and described the falling of great stones in fields and through the roofs of human habitations, the bursting of falling stones in mid-air, and the scattering of the fragments. Still the hypothesis seemed to me to be not altogether groundless in the present instance, and it was strengthened by the known velocity of meteoric stones, which is on an average twelve times as great as that of a musket-ball. Then, too, the time of year and the direction of the projectile favor the opinion that the wound was inflicted by some small stray meteorite. Everybody attributed the wound to a ball from a revolver, because there was no other way to account for it. Had one of the two fellow travelers or one of the laborers in the distant vineyards been in possession of a revolver or other firearm, it would not have been easy for him to clear himself of the suspicion of having shot the man. On this ground, if not on account of its general interest, it is much to be desired that such occurrences should be investigated and published, to the end that, by bringing together and discussing the facts, light might be thrown on this interesting but as yet obscure subject.

Cold-Water Baths.—In some remarks on cold-water bathing in cold weather, the London "Lancet" points out the true use of such baths—which is to stimulate the organism to increased activity, and then shows how this effect is best obtained. A great mistake is made when any part of the body is immersed in cold water and left to part with its heat without any guarantee that the energy of heat-production so severely taxed can respond to the requirement. It may easily happen that the internal heat-production will be exhausted, and if that occurs harm has been done. The obvious principle of health preservation is to maintain the circulation in its integrity; and while the error of supposing that clothing can do more than keep in the heat generated within is avoided, it is not less needful to guard against the evil of depriving the body of the heat it has produced. The furnace should be supplied with suitable fuel, i. e., nutritious food; the machinery of heat-production, which takes place throughout the organism not in any one spot or center, should be kept in working order, and nothing conduces to this end more directly than the free use of the cold douche and the shower-bath; but the application ought to be restricted to a few seconds of time, and, unless the evidences of stimulation—redness and steaming of the surface—are rapidly produced, the effusion should be laid aside. The use of cold water in cold weather is a practice which must be governed by rules special to each individual case. Whether the practice recommended be that of plunging the feet in cold water before going to bed, to procure sleep—which the "Lancet" denounces as "a reckless prescription founded on a physiological fallacy"—or any other use of cold water, the only safe course is to seek the counsel

of a medical man conversant with the patient's peculiarities: particularly in the case of children should this precaution be observed.

Meteorological.—Professor Loomis continues his investigations of the development and phenomena of storms in the United States, in the July number of the "American Journal of Science." In this paper, the eleventh one of the series, it is shown that atmospheric disturbances during storms do not generally extend more than about a mile above the sea-level as they pass over New England. From observations made at the sea-level, as at Portland, simultaneously with observations at the summit of Mount Washington, it is found that during the passage of storms the usual system of circulating winds, does not in a majority of instances extend to a height of six thousand feet. The more violent the movement, however, the greater is the height attained by the disturbance. Another fact of interest is that the disturbance on the approach of a storm is felt at the surface sooner than at considerable elevations. Professor Loomis says that, "when during the progress of an area of low pressure the system of circulating winds reaches to the summit of Mount Washington, the change of wind to the east quarter usually begins at the surface stations eleven hours sooner than it does on the summit of that mountain." It thus appears that only in the lower portions of the atmosphere do the great storm movements occur, and they are first felt at or near the earth's surface.

Why is Music pleasurable?—Darwin, in "The Descent of Man," says of the problem, why musical tones in a certain order and rhythm give man and other animals pleasure, that it is at present insoluble. "We can no more give the reason than for the pleasantness of certain tastes and smells." But Mr. Xenos Clark, in the "American Naturalist," ingeniously essays a solution of this problem, and at the same time offers a theory of the origin of melody. "A musical sound," writes Mr. Clark, "is compound in its structure, being really a group of simple tones heard simultaneously. This group is composed of a ground-tone or fundamental, and a number of overtones, that decrease in intensity as they rise in pitch through a series of harmonic intervals. These intervals, the octave, fifth, fourth, and third, which thus occur in every musical sound we hear, are also at the basis of every human and, I hope to show, extra-human melody . . . . The thought at once arises that the peculiar, compound, harmonic structure of musical sounds has in some way impressed itself upon the auditory mechanism; so that melody, gradually growing under the guidance of the ear thus modified, has been molded into a musical form similar to that possessed by the group of harmonically related tones which we have seen to compose the sounds indicated. This seems very probable. For since each terminal nerve, of the thousands in the cochlea, responds to a given simple tone, the group of such tones forming a musical sound will excite a corresponding group of nerves, which will of course be related among themselves, as are the exciting tones among themselves; that is, they will be serially octaves, fifths, fourths, and thirds apart. Every nerve will therefore have always been stimulated in company with certain others, at harmonic intervals from it; and it is inevitable that the incessant and long-continued repetition of this coöperate activity should have resulted in some anatomical or functional bond; a pathway, as it were, leading from each member of the group to every other. *The progress of any melody will be easiest along this harmonic pathway, worn by the physical structure of sound.*" This would be the origin of melody, and at the same time would explain why musical tones in a certain order give man and other animals pleasure.

The Social Relations of the Future.—The views of Mr. Matthew Arnold on the tendencies of our modern social and political life are very well summed up in a recent number of the "Athenæum" as follows: The inevitable future Mr. Arnold sees to be *democracy:* the many are continually growing less and less disposed to admire, and the few, that is the aristocracy, are becoming less and less qualified to command and captivate. Now, this is not only a fact, but one we should have foreseen long ago, for it is only an example and as-

sertion of that principle of expansion which is a law of nature: in other words, it is natural that all classes and all persons should strive to be heard in matters of moment to the entire community. This being, then, the course which events must take, and which it is even desirable that they should take, we must prepare for the changes it will unavoidably bring about. This must be done in two practical ways: 1. By making the change easier, and this will be done by certain alterations in the laws of bequest and inheritance; and, 2. By making due provision for the new order of things by reforming middle-class education. The state (of which Mr. Arnold accepts Burke's definition, the nation in its corporate and collective character) is to found schools for the middle classes resembling those French *lycées* which have made the middle classes in France so superior to the same classes in England, rather than the "classical and commercial academies" whose advertisements crowd the newspaper columns; and the purpose to keep in view in the bestowal of that education is the awakening of a wider sympathy and a greater tolerance than have hitherto marked the English middle classes. They are to be delivered at once from "narrow Biblism" and from "immense *ennui*." For the rest, Mr. Arnold points out how democracy, instead of being, as it might be, the salvation of the race, may be the end of progress if, in the new conditions, the ideals of life and conduct are less high and less beautiful than of old, and if the arts and other refining influences not bearing immediately on practical life be suffered to fall into disuse and dishonor.

The Argan-Tree of Southwestern Marocco.—Dr. Hooker gives a full and very interesting account of this tree in his "Journal of a Tour in Marocco." It is found on a strip of land about forty miles wide which extends along the coast some two hundred miles. "It is absolutely unknown elsewhere in the world." This tree was first described about the year 1510, by Leo Africanus, who saw it in its native habitat. It is closely allied to the *Siderozylon* (ironwood), a tropical genus. The wood is extremely hard, fine grained, of a yellow color, and apparently indestructible by insects. It is of slow growth, and occurs on sandy soils, and on barren hills, where irrigation is impossible. Not far from Mogador is a large specimen, probably three hundred years old. It measures twenty-six feet in girth. Three immense branches extend from the trunk at only three feet from the ground, one of which rests on the ground and measures eleven feet in circumference. The spread of the branches covers an area seventy feet across. The tree attains only a very moderate height. As the trees throw out branches near the ground, goats frequently climb them to obtain the oily fruit which they bear. Dr. Hooker observes that he had not been accustomed to consider the goat an arboreal quadruped. The oil extracted from the nuts is used by the natives for many domestic purposes, but has a rank and unpleasant flavor, not relished by those unaccustomed to it. About fifty tons is annually consumed. The argan-tree is a striking feature of the plains of Southwestern Marocco. It never forms a dense forest, but is distributed in clumps where few other trees are found.

What Modern Geography includes.—In a memorial addressed by the Council of the London Royal Geographical Society to the Vice-Chancellors of Oxford and Cambridge Universities, the scope and purpose of geographical purposes are defined in the following terms: By geography is meant a compendious treatment of all the prominent conditions of a country, such as its climate, configuration, minerals, plants, and animals, as well as its human inhabitants; the latter in respect not only to their race, but also to their present and past history, so far as it is intimately connected with the peculiarities of the land they inhabit. A scientific geographer does not confine himself to descriptions of separate localities, such as may be found in gazetteers, but he groups similar cases together and draws those generalizations from them to which the name of "Aspects of Nature" has been given. He studies the mutual balance and restraint of the various forms of vegetation and of animal life under different local conditions, and he gathers evidence from the geographical

conditions of the present time on the character of those which preceded and gave rise to them. Of the many classes of problems falling under these heads two are specified: The one deals with the reciprocal influence of man and his surroundings, showing on the one hand the influence of external nature on race, commercial development and sociology, and on the other the influence of man on nature, in the clearing of forests, cultivation and drainage of the soil, introduction of new plants and domestic animals, and the like. The other problem deals with the inferences that may be drawn from the present distribution of plants and animals in respect to the configuration of the surface of the earth in ancient times. Thus we see that the mutual relations of the different sciences is the subject of a science in itself, so that scientific geography may be defined as *the study of local correlations.*

What the Eyes see in reading.—On page 838 of our fourteenth volume we published some remarks by M. Javel on the impairment of eyesight caused by habitual protracted reading. M. Javel has since published some further observations on the mode in which the eye "takes in" the successive letters on a printed page. We are not to suppose, he says, that in reading a line one passes successively from the lower part of a letter to the upper part, then down the next letter, up the next, and so on, the vision describing a wavy line. The fixation takes place with extreme precision along a straight line, traversing the junction of the upper third of the letter with the lower two thirds. Why is this line not in the middle? Because characteristic parts of the letters are more frequently above than below, in the proportion of about seventy-five per cent. That this is so, we can see by applying on a line of typographic characters a sheet of paper covering the line in its lower two thirds, and leaving the upper third exposed. We can then read the letters almost as well as if they had not been concealed in greater part. But the case is very different if we cover the upper two thirds of the line; the lowest third alone does not furnish sufficient for recognition. The characteristic part of the letters, then, is chiefly in their upper portion. M. Javel next compares the ancient typographic characters with those of modern books, and maintains that the latter have too much uniformity, so that, taken in their upper parts alone, many of them may be confounded in reading. The old letters, on the other hand, had each a particular sign by which they could be easily distinguished. The Elzevirian *a*, for example, has no resemblance to *o*, the *r* could not be confounded with the *n*, as now, nor the *c* or *e* with *o*, the *b* with *h*, etc. This too great uniformity in the upper part of typographic characters should be corrected, since it is to that part we chiefly look in reading.

Professor Vaughan on the Origin of the Asteroids.—It is to the general features of the numerous small planets beyond Mars that we must look for a record of their past history. Though most liable to elude the search of the observers, asteroids of great orbital inclination to the ecliptic show already such numbers as to prove a stumbling-block to the usual methods of inquiry respecting the primitive condition of the planetary group. If, as Laplace supposes, they are parts of a ruptured solar ring, they could never deviate far from the plane of Jupiter's orbit by the attractive influence of other planets, and the greatness of the deviation as well as its independence of size excludes the idea of its arising from any mutual action exerted among themselves. The hypothesis of Olbers fails also to meet the difficulty. In the explosion of a single planet moving in the plane of the ecliptic, such an impulse as produced the great inclinations of the paths of Pallas, Euphrosyne, Gallia, Electra, or Artemis, would give cometary orbits to masses launched forth in opposite tangential directions, and cause many asteroids of such an origin to wander far beyond the zone between Mars and Jupiter. Yet the peculiarities in question are precisely such as may be expected in a group of bodies owing their birth to a collision of two planets not very unequal in size or mass. Such an event would be possible when by long disturbance the orbits of both become too eccentric for safety, and when the aphelion of one was in conjunction with the perihelion of the other and near the intersection of their planes. Supposing both or-

bits to touch at the colliding point, the resulting fragments would be driven forth in a plane perpendicular to the course of their common center of gravity. If the velocity from the impulse were thirty-two per cent. of that required for describing a circle, they would be constrained to move in ellipses varying in eccentricity between ·32 and ·1024; and about seven eighths of the known asteroids conform to this limitation in the form of their orbits. Had the motion of both planets been merely progressive and coincident with the ecliptic, the orbital inclination for the fragmentary group would vary from 0 to about 19°, yet the range would pass many degrees beyond this limit through the influence of rotation in the great spheres in causing their matter to fly more rapidly into space in a polar direction in the early stage of the collision. Yet this rotational movement would prevent the eccentricities of the numerous orbits from assuming the proportions which might be expected if the line of motion of the colliding orbs did not pass through their centers as in the supposed case.

There is another clew to the cosmical history of the region between Mars and Jupiter. The orbits of Saturn's moons show a near conformity to geometrical progression, and, taking the common rates at 1·30756, the following table gives the empirical as compared with the actual distances in equatorial semi-diameters of the primary:

Mimas	3·3607	3·3607
Encaladus	4·3933	4·3125
Tethys	5·7488	5·8396
Dione	7·5182	6·8898
Rhea	9·8325	9·5328
	12·8600	.....
	16·8190	.....
Titan	21·9972	22·1450
Hyperion	28·7690	26·7834
	37·6250	.....
	49·2150	.....
Japetus	64·3590	64·8590

It appears from this table that two consecutive satellites are missing in each of the chasms in the Saturnian family, and this evidence of their transformation into asteroids seems more reasonable on considering the disturbing influences of Titan and Japetus on their planetary neighbors. The array of the satellites near Saturn would also lead to the belief of more worlds than one near the sun, and the vain search for Vulcan would render more probable the existence of an asteroidal group within the orbit of Mercury.

Listening to the Pulse.—We take from the "Lancet" an account of a new instrument—the sphygmophone—invented by Dr. Richardson, of London, and which transmutes the movements of the arterial pulse into loud telephonic sounds. The needle of a Pond's sphygmograph is made to traverse a metal or carbon plate, which is connected with the zinc pole of a Leclanché cell. To the metal stem of the sphygmograph is then attached one terminal of a telephone, the other terminal being connected with the opposite pole of the battery. When the whole is ready the sphygmograph is brought into use as if a tracing were about to be taken, and when the pulsation of the needle from the pulse-strokes is secured, the needle, which previously was held back, is thrown over, so as to make its point just touch the metal or carbon plate, and to traverse the plate to and fro with each pulsation. In so moving, three sounds, one long and two short, are given out from the telephone, which sounds correspond with the first, second, and third events of sphygmographic reading. In fact, the pulse talks telephonically, and so loudly, that when two cells are used the sounds can be heard by a large audience.

The Audiometer. — "Audimeter," or "audiometer," is the name given to an instrument invented by Professor Hughes, with the aid of which a person's power of hearing sounds can be very accurately measured. It is formed of a small battery of one or two Leclanché cells, a new microphonic key, two fixed primary coils, a graduated insulated bar, to which at each end one of the fixed coils is attached, a secondary induction coil, which moves along the graduated bar, and a telephone, the terminals of which are connected with the terminals of the induction coil. The principle of the audiometer is based on the physical fact that when the battery is in action, and a current is passing through the two primary coils, the secondary coil on the bar becomes charged by induction whenever it is brought near to either of the primary coils; but, when it is brought to the precise

center between the primary coils, there is a neutral point or electrical balance, where the electrical phenomena from induction cease to be manifested.

In the "Lancet" we find an account of a meeting of the London Royal Society, at which Dr. Richardson demonstrated the action of the audiometer. He was assisted in this demonstration by Professor Hughes, who, by placing a microphonic key between the battery and one of the primary coils, and by attaching the terminals of the induction coil to the telephone, was able to make the telephone produce sounds whenever he brought the induction coil near to one of the primary coils, and moved the microphonic key so as to make it play on a fine needle suspended in the circuit. "When the induction coil is close to one of the primary coils," says the "Lancet," "the noise is very loud, but as the coil is moved toward the center of the bar the noise diminishes, until it ceases at the center altogether. The scale on the bar is graduated into two hundred degrees, representing units of sound from 200 to zero. At 200 all who can hear at all, can hear the vibration of the drum in the telephone. At zero no one can hear, while between the two points there are two hundred gradations of sound, from the highest down to zero."

A Dog's Affection.—The following narrative is from "Chambers's Journal." Some time ago the late Mr. H—— possessed a collie shepherd-dog, which was very clever at its duty until it had a litter, one of which was spared to it. After this all the poor animal's affections seemed to be centered in her puppy, for she refused, or did most unwillingly, the work she had to do, which so vexed her master that he cruelly drowned the puppy before the mother's eyes, covering the bucket in which he left the body with a sack. He then went round the fields, followed by the old dog, who from that moment resumed her former usefulness. On the master's return in the evening, he bethought himself of the bucket and went to fetch it to empty the contents into a hole which he had made in the manure-heap; he found the bucket covered as he had left it, but on pouring out the contents there was nothing but water. He questioned his wife and other inmates of his house, but they knew nothing about it. The next morning Mrs. H—— was struck with the piteous expression of the poor animal's face, and said to her, "Scottie, tell me where you have taken your puppy." The dog immediately ran off a distance of one hundred yards to the kitchen garden, jumped the fence, and went direct to the farther end of the inclosure to a spot situated between two rows of beans; there, where the earth had apparently been recently moved, she sat, and as it were, wept. Mrs. H—— went again into the house, and without mentioning what had occurred, said to her niece, "Ask Scottie what she has done with her puppy." The question was put, and again the poor creature went through the same performance. These circumstances were mentioned to Mr. H——, who pooh-poohed the idea of there being anything out of the common; but to satisfy his wife he went to the spot and dug down a distance of three feet, and there, sure enough, had the faithful, fond mother buried her little one!

Sympathy in an Ants' Nest.—According to Sir John Lubbock's observations, ants belonging to the same nest never quarrel among themselves; he has never seen any evidence of ill-temper in any of his nests. Again, ants appear to show great kindness to inmates of their own nests which happen to be in straits. In one of Sir John's nests of *Formica fusca* was a poor ant which had come into the world without antennæ. Never having previously met with such a case, he watched her with great interest, but she never appeared to leave the nest. At length one day he found her wandering about in an aimless way, apparently not knowing whither to turn. After a while she fell in with some specimens of *Lasius flavus*, who directly attacked her. He rescued her, but she was evidently badly wounded, and lay helpless on the ground. After some time another *F. fusca* from her nest came that way, examined the poor sufferer carefully, then picked her up and carried her away into the nest. It would have been difficult, Sir John Lubbock thinks, for any one who witnessed this scene to have denied to the ant the possession of humane feelings.

Fossil Rhinoceros in Siberia.—In a communication to "La Nature," A. Hoffmann, of Moscow, announces the discovery, in Siberia, of the head of a rhinoceros (*Rhinoceros tichorhinus*), which still retains, in a wonderful state of preservation, nearly all its covering of flesh. "This head," he writes, "was found near a small stream, called the Balantaï, a tributary of the Yany, at the distance of some 200 versts from the city of Vorshvianska. M. Gorokoff, to whom we are indebted for this discovery, made haste to communicate with the Imperial Geographical Society of St. Petersburg. A member of that Society, M. Tshersky, to whom the head was submitted for examination, says that it must have belonged to a young animal, for some of the teeth had not as yet quite come out from their alveoli. The entire head is covered with a strong tissue, hardened by time; but one side of it is badly injured. Here the flesh is in part decayed, and crumbles away. A portion of the skull is bare, and we can see the dried muscles and veins; also, a portion of the spinal marrow, the latter having dropped out of the passage through the second cervical vertebra. This curious fossil head retains in perfect preservation the muzzle, the lips, the ears, the hair of half of the left side, a good part of the forehead, and on the right side the upper portion of the neck, and several other parts. Further, we notice the places for two horns."

Drilling Rocks by Electricity.—M. Gaston Planté suggests a novel use for electricity, namely, as a borer of rocks, taking the place of the black diamond. "We have seen," he writes in a volume recently published, "that one of the electrodes which conveys a current of a certain electromotive force, on being put in contact with glass in presence of a saline solution, acts as a graver or diamond in cutting furrows on the surface of the glass, plowing it even deeply. Rock-crystal can also be attacked, despite its hardness, by the same method, and, if it does not yield regularly, it at last bursts into pieces under the action of the electrode, and ends by breaking up. In America black diamonds are employed in rock-drilling for wells and mines. Could these expensive tools not be replaced by the action of the electric current in conditions analogous to those which have been described, and the perforation of rocks be performed by electricity? Electrodes of platinum would not be necessary, for it is not the metal of the electrode which alters, but the silicious matter in presence of the saline solution. Metallic points or studs conveniently distributed at the end of the drill and put in rotation, would direct the electric discharge to the rock, which it would pulverize, as in the case of the diamond drill. The recent advances in the production of electricity by mechanical means would facilitate this application."

Mr. Gladstone on Natural History Studies.—Mr. Gladstone, in addressing the pupils of a Nonconformist school at Finchley, England, advocated a more important place in our systems of education for natural history. "Natural history," he said, "is a continual lesson—a lesson at once easy and profound—of the wisdom and beneficence of Providence; a continual confirmation of belief, when you find the wonderful hand of that Workman descending to the smallest object with the same care with which he mounts to the greatest. The religious use of natural history is one that all must delight in. Again, learning is an admirable thing, but it does not always make itself agreeable at the first introduction. But it certainly is a marked advantage in the study of natural history that it leads you on by the hand—it inveigles you, so to speak, into learning what is good and what is useful. Many a one might have his mind first opened by the attractions of natural history, and, once opened, it might perhaps be capable of applying itself beneficially to harder and more repulsive studies. Natural history, too, is one of the best and most efficient means of educating the senses. It may, perhaps, be suggested that the senses are educated well enough already, and claim quite a large enough portion of our existence. That, of course, is perfectly true so far as the grosser forms of enjoyment are concerned; but so far as the senses are connected with the acquisition of knowledge, they are very indifferently educated indeed. The habit of minute, careful, and accurate observation, which is inseparable from such a study as

that of natural history, gives that power of accurate deduction which is invaluable in the pursuit of every branch of knowledge. We all know, I may add, how much has been done in the researches of our time by applying the principle of comparison—comparison, for example, of the structure of living bodies as the basis of modern biology, the comparison of the structures of languages as the basis of philology. Depend upon it, then, that the observation and analogy which natural history is continually suggesting, as it is valuable for the purposes of science, so it has a lighter but a most graceful and civilizing use in supplying those analogies taken from the seen world and applicable to the unseen, assisting in giving to every work of the mind that grace and beauty which is just as appropriate and desirable, though it may not be so indispensable to it, as are the higher qualities of solidity and truth."

How the "Goat-Suckers" came by their Name.—Mr. A. R. Wallace calls attention to an interesting observation made by Charles Waterton, which throws some light on the origin of one of the superstitions of natural history. Ever since the time of Aristotle, at least, the belief has prevailed that the bird known as the "goat-sucker" (*Caprimulgus*) actually sucks goats or cows. According to Pliny, the goat-sucker "enters the fold and flies to the udders of the goats in order to suck the milk." The fact that the birds "fly to the udders" of the animals is confirmed by Waterton, but at the same time he shows how erroneous is the inference that they suck the milk. "I am fully persuaded," writes that ingenious observer, "that these innocent little birds never suck the herds, for when they approach them, *and jump up at their udders*, it is to catch the flies and insects there. When the moon shone bright I would frequently go and stand within three yards of a cow, *and distinctly see the caprimulgus catch the flies on its udder*." In another place he writes: "When the moon shines bright you may have a fair opportunity of examining the goat-sucker. You will see it close by the cows, goats, and sheep, jumping up every now and then under their bellies. Approach a little nearer—see how the nocturnal flies are tormenting the herd, and with what dexterity he springs up and catches them, as fast as they alight on the belly, legs, and udders of the animals. Observe how quiet they stand, and how sensible they seem of his good offices, for they neither strike him nor hit him with their tails, nor tread on him, nor try to drive him away as an uncivil intruder."

Geographical Distribution of Bats.—At a meeting of the "Scientific Societies of the Departments," lately held at Paris, a report of which is given in "La Nature," Dr. Trouessart, under the title of "Geographical Distribution of the Bats" (*Cheiroptera*), read a paper, of which the following is a summary: There are certain species of bats which pass the winter in a state of torpor in caverns or in abandoned quarries—for example, the horseshoe bat—or in the hollows of trees, under the roof-timbers of houses, or in crannies in the walls—as the *Pipistrella*, so common in cities, which, awakening during very mild winters, is sometimes seen flitting about in January. But it is an error to suppose that all bats hibernate. Many *Cheiroptera* migrate after the manner of birds, and this fact accounts for the reduction of the number of species from eight hundred to four hundred, as distinctions of species had been set up merely on the ground of the great distance between localities. Many species of bats seen in France are migratory, and are found there only in the summer months, having come in pursuit of the insects on which they subsist. Of twenty-five species occurring in Europe, at least twenty-two are found also in eastern Asia. Bats possess considerable power of flight. The flying fox (*Pteropus rubricollis*) of the tropical parts of the Old World can at one flight compass a distance of thirty leagues. This vigorous power of flight explains the presence of *Cheiroptera* in Australia, where they are the only native *Monodelphs*, as also in the islands of Polynesia and in New Zealand, a country rich in its avifauna, but which, with the exception of several species of bats, possesses no mammals save those purposely introduced by man, and the rats and mice brought by ships. Of the six families of the order *Cheiroptera*, the *Phyllostomata* are exclu-

sively American; the *Emballonura* have only one representative in Europe—a *Molossus* found on the shores of the Mediterranean, and which visits Switzerland in summer; two species of *Rhinolophus* (the great and the less horseshoe bat) are found in Great Britain, and the former of these species is distributed as far eastward as Japan. The *Vespertilios* constitute a truly cosmopolitan family, extending in latitude from the border of the Arctic region down to the Strait of Magelhaens. The *Serotina* occurs throughout Europe, in Asia, and in Africa down to the Gaboon; and one race of this species is found in America as far south as Guatemala. But in those parts of both hemispheres which lie farther south, the *Serotina* is succeeded by nearly allied species of the same subgenus *Vesperus*. Of fossil *Cheiroptera* we have but very few. The gypsum strata of Montmartre have yielded to science *Vesperugo parisiensis*, which is closely analogous to, if not identical with, the *Serotina* of France. Again, among the Eocene *Cheiroptera* of North America described by Marsh occurs a *Serotina*, resembling the race now existing in the same region. And as the power of flight possessed by the *Cheiroptera* accounts for their geographical distribution (which is analogous to that of birds), so, too, it affords a probable explanation of the inconsiderable changes which the order has undergone since Tertiary times. Undoubtedly it is through this power of flight that they were enabled to escape amid the geological cataclysms which long ago annihilated the giant land mammals which were their contemporaries in the Eocene.

Ancient American Pottery.—A very remarkable collection of ancient American pottery is now on exhibition at No. 77 Maiden Lane, New York. It consists of about twelve hundred pieces, and is the fruit of explorations conducted by Mr. J. A. McNiel in an ancient cemetery in Chiriqui, Panama. The graves in which these articles of pottery were found lie scattered along the Pacific slope of the foot-hills of Mount Chiriqui, and the "cemetery" covers thousands of square miles. The graves do not appear to have been disposed according to any definite plan, nor do they lie with reference to any one point of the compass. They are found at varying depths, sometimes being as much as fifteen feet below the surface, and sometimes not more than two or three feet. Many of them appear to have been opened again and again for successive interments. They are walled up on the sides and at the ends with large round stones, which are plainly water-worn, and must have been brought from river-beds at a considerable distance. The graves are covered with flat stones, some of them weighing three hundred pounds. These stones do not belong to the local formations, and can only have been procured from situations several miles distant up the mountain-side. As there are no indications on the surface as to where the graves are hid, they are discovered by thrusting an iron rod into the earth till it strikes a stone. The articles of pottery found in these graves are principally jars and tripods, with a few small objects, toys, and whistles, and certain thin, flat disks pierced with a hole in the center, that may have served as wheels of toy carts.

Adulteration of Drugs.—In France all pharmacies are subject to inspection with regard to their general management, and more particularly to their practice in dispensing poisonous substances, and to the purity of the drugs and medicines kept on sale. But even in that country unscrupulous pharmacists are found who palm off upon the public adulterated drugs. Indeed, so common is this practice that careful physicians, whenever they prescribe any medicine that is difficult to prepare or specially costly, are wont to advise their patients to have the prescriptions made up only by pharmacists of approved integrity. At a meeting of one of the medical societies of Paris the following instance was given of the ill effects of using adulterated medicines: A physician having been called to attend a girl suffering from a violent attack of fever, prescribed a strong dose of quinine sulphate, hoping thus to prevent, or at least to mitigate, the second attack. But this second attack was worse than the first, and the patient's condition became very serious. Seeing that the quinine was without effect, the physician procured some of it for analysis, and procured at a reputable pharmacy another dose of the drug. This having been administered to the patient, the third attack

of the fever was far less violent than the two preceding. The analysis showed that the suspected quinine sulphate was strongly adulterated with salicine.

NOTES.

LARGE numbers of *Trichina spiralis* have been detected in cured meats imported into Alsace from America. In Switzerland, too, the discovery has been made that American hams are full of the trichina, and a government commission has been appointed to decide upon the precautionary measures to be taken. The cantonal authorities are recommended to warn the people against the use of American hams, especially in the half-raw state, and to arm the police with discretionary powers over the sale of the article.

ON the 2d of June the Paris Academy of Sciences elected Professor Huxley to be a corresponding member of the Academy for the section of anatomy and zoölogy. Professor Huxley received 41 votes out of a total of 49; Agassiz received 5 votes, Bischoff 1, and there were two blank ballots.

A NEW method of excavating for the erection of telegraph-poles has been devised and put to the test at Titusville, Pennsylvania. A man drives a crowbar into the ground to the depth of four or five feet, and into the hole so made drops a four-ounce cartridge of so-called "electric powder." The fuse having been lighted, the man proceeds to the site of the next pole. In the mean time a dull sound is heard, and a hole about the diameter of a flour-barrel, and four or five feet deep, has been made by the exploding cartridge.

To meet the convenience of students, and thus remove the sole objection in the minds of professors to the extended use of an admirable series of text-books, Macmillan & Co., the publishers of the well-known "Clarendon Press Series of Educational Works," issued under the direction of the delegates of Oxford University, have in preparation a new nett catalogue of those works, as well as of their own educational works, which will be ready early in the fall.

THE utilization of bamboo for paper-making is advocated by a writer in the "Journal of the Society of Arts," who pronounces it far superior for that purpose to esparto-grass. Then, too, it can be produced at less cost than esparto. By utilizing the bamboo spontaneously produced in India, or, better still, by cultivating the plant there, an unfailing supply of the fiber might be produced.

MR. W. MATTIEU WILLIAMS, who for more than thirty years has closely studied the subject of the electric light and noted every new development, does not hesitate to affirm that "although as a scientific achievement the electric light is a splendid success, its practical application to all purposes where cost is a matter of serious consideration is a complete and hopeless failure, *and must of necessity continue to be so!*"

THE amount of labor performed by bees in collecting honey may be seen from certain calculations made by Mr. Andrew Wilson. He finds that 125 heads of clover yield approximately one gramme of sugar (about 15½ grains), and that 125,000 heads yield one kilogramme (2·2 pounds). Now, as each head of clover contains about 60 florets, it follows that the bees must suck 7,500,000 distinct florets in order to obtain 2½ pounds of sugar. And as honey roughly may be said to contain 75 per cent. of sugar, we have one kilogramme, equivalent to 5,600,000 flowers in round numbers, or say 2,500,000 visits for one pound of honey.

THE custom of persons bearing two "Christian names" is of comparatively recent origin in England. An author, who has had occasion to search many volumes of old country records, and who has seen "many thousands and tens of thousands of proper names belonging to men of all ranks and degrees," says that in no instance, down to the end of the reign of Anne, has he noticed any person having more than one Christian name. The first instance which occurs in the county records was in 1717, when Sir Coplestone Warwick Bainfield appears as a justice. The first instances which the same author has met in any other place are those of Henry Frederick, Earl of Arundel, born 1608, and Sir Henry Frederick Thynne, created a baronet in 1641. Both of these appear to have been named after the eldest son of James I., who was born in Scotland. William III., who was a Dutchman, was the first King of England who bore two Christian names.

PROFESSOR STOKES, of the University of Cambridge, England, has been elected a corresponding member of the Paris Academy of Sciences. The German Emperor has also conferred upon him the decoration of the order "Pour le Mérite."

DR. WINNECKE, of Strasburg, has discovered a record of observations made in 1580, or at least thirty years before the invention of the telescope, in which the places of eleven stars of the Pleiades are given. On comparing these with modern observations, it appears that the places were determined with a probable error of only 2′; hence there can be little doubt that all these stars were seen by the naked eye.

GEORGE F. BARKER.